NIST Proposed Provisions for a Rulemaking on Test Procedures for Commercial Water Heaters, Boilers, Furnaces, Air Conditioners and Heat Pumps

FILE Q:\data\ee-40\ee-43\43common\nasseri\nistrep\nistrept.wpd
October 2, 1998 (9:35AM)

Table of Contents

1.0 Background

Part B of Title III of the Energy Policy and Conservation Act (EPCA) of 1975, Pub. L. 94-163, as amended, by the National Energy Conservation Policy Act of 1978 (NECPA), Pub. L. 95-619, the National Appliance Energy Conservation Act of 1987 (NAECA), Pub. L. 100-12, the National Appliance Energy Conservation Amendments of 1988 (NAECA 1988), Pub. L. 100-357, and the Energy Policy Act of 1992 (EPAct), Pub. L. 102-486, established the Energy Conservation Program for Consumer Products other than Automobiles. Part 3 of Title IV of NECPA amended EPCA to add ``Energy Efficiency of Industrial Equipment," which includes commercial package air conditioning and heating equipment, packaged terminal air conditioners and heat pumps, warm air furnaces, packaged boilers, storage water heaters, instantaneous water heaters, and unfired hot water storage tanks.

EPAct also amended EPCA with respect to these equipment, providing definitions, test procedures, labeling provisions, energy conservation standards, and compliance certification requirements in various sections.

The Department of Energy has an energy conservation program for consumer products, conducted pursuant to Part B of Title III of EPCA, 42 U.S.C. 6291- 6309. Under EPCA, the consumer appliance standards program essentially consists of three parts: Test Procedures; Federal energy conservation standards; certification and enforcement procedures. The program is codified in Title 10 of the Code of Federal Regulations, part 430--Energy Conservation Program for Consumer Products.

Since 10 CFR part 430 covers consumer products as distinct from commercial and industrial equipment, the Department of Energy is creating a new part 431 in the Code of Federal Regulations (10 CFR part 431), Energy Conservation Program for Commercial and Industrial Equipment, to cover certain commercial and industrial equipment covered under the Act. These will include commercial heating and air-conditioning equipment and water heaters. This new commercial and industrial equipment program will consist of the same elements as the program covering consumer products: Test Procedures; Federal energy conservation standards; labeling; and certification and enforcement.

FILE Q:\data\ee-40\ee-43\43common\nasseri\nistrep\nistrept.wpd
October 2, 1998 (9:35AM)

2.0 Introduction

The Department of Energy (DOE) is currently drafting proposed rules to implement the Energy Policy and Conservation Act (EPCA), 42 U.S.C. 6314, provisions for energy efficiency test procedures and standard compliance concerning commercial water heaters, boilers, furnaces, air conditioners and heat pumps. While EPCA calls for the adoption of American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 90.1, several issues need to be resolved concerning how the Standard should be interpreted and applied.

2.1 April 1998 Workshop

On April 14 and 15, 1998, DOE convened a public workshop to solicit from interested parties views and information that would aid in the development of these rules, and it requested comments on a number of specific issues, including the most appropriate interpretation of ASHRAE Standard 90.1 as it applies to the covered equipment, as well as the most cost- effective and reliable regimes for sampling, certification and enforcement. Statements received during the public workshop and written comments afterwards have helped to refine the issues involved in this rulemaking and have provided useful information contributing to their resolution.

2.2 Current Report

Since the April 1998 workshop, DOE and the National Institute for Standards and Technology (NIST) have been working together to address the issues and to outline the test methods and other provisions that might constitute provisions of the proposed rules. The result is a set of recommendations by NIST, contained in this report.

This report is expected to serve as a basis for discussions during a second workshop to be held on October 13, 1998, in order to elicit further views and information from interested parties. DOE's objective is to air NIST's recommendations, as they appear later in this report, and to seek reactions from the participants that will aid in considering whether and in what form to include the recommendations in the corresponding notices of proposed rulemaking.

The discussed issues are listed and summarized within Section 3 and detailed discussions of individual issues appear in Section 4, Proposed Provisions. For each covered product category, NIST has developed a discussion of the related issues, followed by recommended uniform test methods that reflect staff thinking on how the issues should be resolved. A subsection also covers the compliance certification and enforcement sampling procedures, which would apply generally to all of the equipment categories. A milestone chart, summarizing the steps leading to the publication of the final rule and including the projected time line, appears in Section 5.

The draft CFR language for the test procedures and sampling provisions appear in the Appendices.

3.0 Key Issues and NIST Recommendations

This section contains a summary of key issues discussed during the April 1998 workshop or raised in the written comments afterwards, along with NIST recommendation concerning each issue. Individual issues and recommendations are discussed at greater length in the numbered sections that are referred.

3.1 Commercial Equipment Sampling, Certification and Enforcement

Compliance Certification

Issue	NIST Recommendation
• Where should testing be performed and by whom?	• Due to the unique characteristics of commercial HVAC & water heating equipment, an alternative approach to the current compliance testing procedure for consumer products, is being proposed. (See 4.1.1) • Adopt a certification plan which incorporates the determination of efficiency based on testing conducted by or for the manufacturer and reported to DOE, either directly or through a designated industry organization. (See 4.1.2) • NIST recommends incorporating a provision for voluntary independent certification program of covered equipment, implemented at the discretion of DOE. (See 4.1.4)
• What is the appropriate sample size for each product to be tested?	• The number of units to be tested, and the method for determining the mean efficiency are left to the discretion of the manufacturer. However, all test results and related analysis used in the determination of the mean must be maintained by the manufacturer as a permanent record. (See 4.1.2)
• How should sample units be selected?	• The individual units tested shall be representative of the basic model, and a sufficient number shall be tested to ensure that an accurate estimate of the

	mean efficiency of the basic model can be determined. (See 4.1.2)
• How should compliance be determined from test results, e.g. by employing arithmetic averaging or statistical confidence intervals?	• The value for efficiency shall be that which the manufacturer determines to be the mean for all of the units of that basic model, using any valid statistical method, and shall be based on the results of testing in accordance with the applicable test procedure. (See 4.1.2)
• Should derating or other special adjustment factors be used?	• No derating or special adjustments recommended, except for the purpose pf verification testing. (See 4.1.4)
• Is simulation testing a valid approach? Should limits be placed on its use?	• The efficiency of a basic model could be determined using analytical procedures such as computer modeling or other approaches, as long as those procedures have been verified and validated using testing results. (See 4.1.3) • Written documentation demonstrating the validation of such analytical procedures must be maintained as a permanent record, and must be approved by a registered professional engineer. (See 4.1.3)

<u>Enforcement Sampling</u>

Issue	NIST Recommendation
• Should the scheme applied in enforcement differ from that used for compliance?	• Keep essentially the same enforcement regulations for commercial HVAC & water heating equipment as are in place for other covered products. The exceptions appear in the next issue. (See 4.1.5)
• Are special provisions needed for very large capacity, site-assembled, or low production quantity units? • Can equipment be grouped as minor variations on a more limited number of	• Allow special provisions for equipment which are manufactured in very small quantities, or which are very large in size. — If the total number of available units of a

basic models? If so, how many models need to be tested, and what is the best way to extrapolate the results to other equipment within a group?	basic model involved in an enforcement action is less than four, then all of the units shall be tested. (See 4.1.5) — An exception would be available for very large units on a case-by-case basis, such that only a single unit would be tested.(See 4.1.5)
• Should the enforcement sampling plan be used to determine the validity of labeling representations?	• Not an issue in the absence of a labeling rule.

3.2 Test Protocols for Commercial Water Heaters, Instantaneous Water Heaters, and Unfired Hot Water Storage Tanks

Clarification of Coverage and Definitions

Issue	NIST Recommendation
• General: Would it be beneficial to include a table similar in format to Table 7.2.2 of 90.1R in the proposed rule in order to clarify the categories of coverage for commercial water heaters?	• A table will be provided to show EPAct-covered product and requirements as is done in 10 CFR 430 subsection 32
• General: ANSI Z21.10.3-1990 has been revised. The current version, Z21.10.3-1993, contains no modification of the test procedures for thermal efficiency and standby loss. Should the reference to this test procedure in Table 11.1 be updated to the 1993 version?	• ANSI Z21.10.3-1993 incorporate by reference as indicated by ASHRAE Standard 90.1-1989 Addendum n.
• Electric Storage Water Heaters: Is there any reason why the ANSI test procedure should not be applicable to electric storage water heaters with input ratings between 12 and 22 kW?	• No.
• Gas-Fired Instantaneous Water Heaters: Should Table 11.1 be clarified to indicate that only gas-fired instantaneous water heaters with input ratings greater than 200,000 Btu/h are EPAct-covered equipment?	• Instantaneous water heaters designed to heat water to temperatures of 180°F or higher may be subjected to the energy conservation standards of commercial equipment regardless of the input rating. (See 4.2.2)
• Oil-Fired Instantaneous Water Heaters: Should Table 11.1 be clarified to indicate that all oil-fired instantaneous water heaters with input ratings greater than 210,000 Btu/h are EPAct-covered equipment?	• Instantaneous water heaters designed to heat water to temperatures of 180°F or higher may be subjected to the energy conservation standards of commercial equipment regardless of the input rating. (See 4.2.2)

• Commercial Water Heater or Packaged Boiler: Which test procedure, if any, should be used to test boilers as commercial water heaters?	• Based on comments by CEC and GAMA, NIST recommends that if a packaged boiler is used to supply service hot water, it should be tested and rated as a hot water heater for its thermal efficiency rating. If the same boiler is used for space heating purpose, it should be tested as a packaged boiler for its combustion efficiency rating. (See 4.2.2)

Standby Loss Testing

Issue	**NIST Recommendation**
• Should the R-value be considered to be an “effective” R-value which would account for heat losses through the insulation due to thermal bridges?	• No. (See 4.2.3)

Unfired Storage Tanks

Issue	**NIST Recommendation**
• What test procedures are available for use in determining the rate of heat loss per square foot of tank surface area?	• None were identified during the workshop.
• If procedures are available, which should DOE require? If not, is a new procedure needed?	• NIST is developing one based on ANSI Z21.10.3-1993.

3.3 Test Protocols for Commercial "Packaged" Boilers

<u>Definition of "Packaged Boiler"</u>

Issue	NIST Recommendation
• Is the EPACT's definition for packaged boiler clear enough? To what extent, if any, are custom-designed, field-assembled boilers excluded? Is a size limit implicit in the definition of "commercial packaged boiler," and if so what is the maximum capacity?	• NIST believes that the definition of a packaged boiler is clear enough to exclude custom-design (for a specific installation), field-constructed (as opposed to a re-assembly of major sub-assemblies disassembled for shipping purpose) boiler system. While the size is not implicit, the rule should be confined to low-pressure boilers. (See 4.3.1)

<u>Combustion Efficiency; Jacket Losses</u>

Issue	NIST Recommendation
• <u>Efficiency</u>: ASME PTC4.1 includes parasitic electric energy in its efficiency calculation. Should parasitic electric energy be considered in combustion efficiency?	• NIST recommends that parasitic electric energy be ignored as heat input in combustion efficiency calculation.
• <u>Jacket Loss</u>: Not all the ASHRAE 90.1-1989 referenced test standards include test and calculation methods for jacket loss. Only ASME PTC 4.1 provides a graph for jacket loss and a test method also. (1) If a jacket loss term is needed, should a single method be selected for jacket loss test? (2) Should laboratory test results be adjusted to (average ?) outdoor conditions?	• Since the referenced test procedures (ANSI Z21.13 and HI Std.-1989) for low-pressure steam and hot water boilers do not include jacket loss test, and the calculation of the combustion efficiency does not require the term jacket loss, NIST recommends that jacket loss (radiation loss in ASME PTC 4.1) test not be required in the test procedure.

Uniformity of Test Conditions, Test Setup, and Procedures

Issue	NIST Recommendation
• There are differences among the various referenced test standards. In cases where more than one procedure is applicable to the same product, do the different procedures yield the same result? If not, which procedure is the sounder in each instance?	• NIST recommends that the HI-1989 standard be referenced as a single uniform DOE test standard for commercial, packaged, gas and oil fired, low-pressure steam and hot water boilers for space heating application, with the provision that the inlet water temperature for hot water boilers be specified at 80 ±10°F and the outlet water temperature for hot water boilers be set at 180 ±2°F as specified in ANSI Z21.13-1993a. (See 4.3.2).
• For flue gas temperature measurement, should a 9-thermocouple grid be an option instead of the single temperature sensor measured successively at 9 points? To obtain a more accurate flue gas temperature for the flue loss method, should insulation of the flue pipe up to the temperature measurement plane be required?	• NIST recommends that the HI-1989 standard be referenced as a single uniform DOE test standard for commercial, packaged, gas and oil fired, low-pressure steam and hot water boilers for space heating application which specifies the thermocouple grid for flue gas temperature measurement and the insulation of the flue pipe.

Provisions for Other Design Features

Issue	NIST Recommendation
• Should two test conditions with respect to water inlet and outlet temperatures be specified for hot water boilers for high temperature and low temperature applications?	• NIST agrees with the comments from the workshop attendees and does not recommend a different set of test inlet and outlet water temperatures for applications that require a low supply and return temperature setting. (See 4.3.2)
• None of the referenced test standards specify a test procedure for condensing boilers. Should a test procedure for flue condensate measurement be developed for condensing boilers? If so, should the	• NIST recommends that the test procedure (under steady-state condition) for flue condensate measurement as specified in ASHRAE 103-1993 be offered as an optional test procedure for

procedure in ASHRAE 103-1993 be considered/adopted?	condensing boilers.
• Should DOE adopt the two rating conditions (at the maximum and the minimum input rates) for modulating boilers as specified in ASHRAE 90.1-1989?	• It is NIST's understanding that DOE agrees with the comments from the workshop that since the statute only requires rating at the rated input, only testing at the rated input shall be required.
• Should a single boiler be tested for a modular boiler assembly?	• NIST recommends that for those types of commercial packaged boiler installations, a single boiler from the assembly be tested and its efficiency be applied as the efficiency rating of the boiler assembly. (See 4.3.2)
• Should a hot water/steam boiler be tested on steam only?	• NIST is proposing that manufacturers be allowed the option of reporting the efficiency rating of a steam and hot water boiler from the test result obtained by testing the boiler as a steam boiler. (See 4.3.2)

3.4 Test Protocols for Commercial Warm Air Furnaces

<u>Thermal vs. Combustion Efficiency; Jacket Losses</u>

Issue	NIST Recommendation
• <u>Efficiency</u>: In cases where EPACT specifies thermal efficiency and the referenced test procedures listed in ASHRAE 90.1 measure combustion efficiency, should DOE require a procedure to measure thermal efficiency as OUTPUT/INPUT, or should it specify a method for correcting combustion efficiencies with jacket losses to obtain thermal efficiencies? Should the term "thermal efficiency" be taken in practice to mean the same thing as combustion efficiency, as prescribed by ANSI Z21.47-1993?	• As per DOE, the statute defines the energy descriptor for a commercial warm air furnace as the thermal efficiency and it should not be changed, therefore NIST recommends that, DOE define the term thermal efficiency for a commercial warm air furnace as 100% minus the percent flue loss, as prescribed in the referenced ANSI Z21.47. (See 4.4.3)
• <u>Jacket Loss</u>: ANSI Z21.47 provides a test procedure to measure jacket loss. Should laboratory test results be adjusted to (average ?) outdoor conditions?	• Based on the comments from the workshop attendees, NIST recommends that no adjustment to outdoor condition be made to the jacket loss test procedure as prescribed in ANSI Z21.47.

<u>Provisions for Other Design Features</u>

Issue	NIST Recommendation
• Should DOE adopt the two rating conditions (at the maximum and the minimum input rates) for modulating furnaces as specified in ASHRAE 90.1-1989?	• It is NIST's understanding that DOE agrees with the comments from the workshop that since the statute only requires rating at the rated input, only testing at the rated input shall be required.
• None of the referenced test standards specify test procedure for condensing furnaces. Should a test procedure for flue condensate measurement be developed for condensing furnaces ? If so, should the procedure in ASHRAE 103-1993 be considered/adopted?	• NIST recommends that the test procedure (under steady-state condition) for flue condensate measurement as specified in ASHRAE 103-1993 be offered as an optional test procedure for condensing furnaces.

3.5 Test Protocols for Commercial Air Conditioners and Heat Pumps

<u>"Heating Only" Heat Pumps</u>

Issue	NIST Recommendation
• Are "Heating Only" heat pumps covered equipment?	• NIST observes that the statute does not cover this equipment. This determination is of little practical consequence because heating-only heat pumps are neither available on the U.S. market at this time nor are expected any time soon. (See 4.5.2)

<u>Computer Room Air Conditioners</u>

Issue	NIST Recommendation
• Are computer room air conditioners covered equipment?	• NIST observes that these equipment are special purpose equipment with distinct design features and are not covered, when used primarily for cooling computers (see 4.5.3)

4.0 Discussion of Proposed Provisions

4.1 Sampling, Certification and Enforcement

4.1.1 General Discussions

The purpose of establishing regulations concerning certification and enforcement is to provide a basis for assuring that covered commercial HVAC & water heating equipment which are certified as being in conformance with applicable energy conservation standards actually comply with those standards.

NIST recommends a set of provisions concerning compliance certification and enforcement procedures for covered commercial equipment. Compliance with energy conservation standards would be assured in part by having each manufacturer certify that its covered equipment complies with the applicable energy conservation standards. In addition, enforcement procedures would be specified for use in resolving any disputed performance claims for covered equipment.

For consumer products, the test procedure for each class of equipment incorporates a sampling plan designed to give a reasonable assurance that the true mean performance of the equipment being manufactured and sold meets or conforms to the DOE energy efficiency standard. The mean performance is selected as the critical performance characteristic of covered equipment because it determines the overall energy usage of a covered equipment population, and thus the impact of the equipment on national energy consumption.

Individual units produced from a single design may vary in energy efficiency for a number of valid reasons, including variability in manufacturing and testing. The risk to the public of purchasing a non-complying unit, and the burden on the manufacturer in conducting performance testing, must be balanced to provide adequate protection for the public without imposing an excessive testing burden on the manufacturers.

Given that performance testing of every unit of a covered product would be prohibitively expensive and time-consuming, the average performance of the basic model must be estimated through evaluation of a sample drawn from the population. The method by which an estimation of equipment performance is derived from a small sample of a large population is called a sampling plan.

Prior to the DOE workshop in April, NIST anticipated that compliance certification and enforcement sampling procedures for commercial equipment would be similar to those established in the past for consumer products. These require manufacturers to certify compliance based on testing under strictly prescribed statistical sampling schemes designed to assure, with reasonable probability, that the average efficiency of each product sold meets the applicable standard.

Enforcement involves a similar, but not identical statistical sampling arrangement. The advantage of this approach is that manufacturers can provide adequate assurance of compliance without having to incur the cost of testing every single unit they produce.

When presented with the concept of applying a prescribed statistical sampling method to certifying commercial equipment, participants at the workshop made three general observations:

- A workable uniform sampling method covering the wide variety of commercial equipment would be difficult, if not impossible to formulate. This is due to the large number of design variations and small numbers of identical units for some equipment.
- The State of California and several voluntary industry associations already have effective efficiency certification programs in place that leave the sample design to the manufacturer.
- With adequate independent verification and penalties for improper certification, prescribing the sampling scheme is unnecessary, since the manufacturers will have an incentive to design one that limits the risk of being caught out of compliance.

With these observations in mind, NIST investigated the certification programs of the State of California, the Air Conditioning and Refrigeration Institute, the Gas Appliance Manufacturers' Association, and the Hydronics Institute. All of these programs entail some form of independent verification or supervision of tests carried out by the manufacturer, and each contains penalties that appear adequate for the purposes of assuring that testing would occur, and that certified efficiencies would be reliable. On the other hand, some manufacturers do not participate in voluntary industry programs, and no program exists at present for commercial furnaces, so DOE would need its own certification testing and verification arrangement, at least for equipment not otherwise covered.

NIST therefore recommends that DOE require manufacturers to certify compliance based on testing under a prescribed sampling scheme or on testing performed under DOE approved voluntary independent certification programs.

The operating procedures of three existing industry certification programs are summarized below:

- For commercial air conditioners, the program is operated by the Air-Conditioning and Refrigeration Institute (ARI). This is a voluntary program that allows participating manufacturers to certify the performance of their equipment, and which conducts periodic verification testing of performance claims. Equipment performance values are listed in a directory that is available to the public. The existence of this industry program increases the likelihood that energy efficiency representations of covered air conditioners are accurate, at least for participating manufacturers. ARI claims that over ninety percent of the manufacturers of covered commercial air conditioners participate in this voluntary certification program. Furthermore, the manufacturers maintain that the ARI program is effectively policing the marketplace, and thus additional testing and certification requirements are unnecessary.
- For commercial boilers, the program is operated by the Hydronics Institute (HI) for the Gas Appliance Manufacturers Association. This is also a voluntary program which conducts certification testing of boilers at the manufacturer's test facility. Equipment performance values are listed in a directory that is available to the public. The HI certification program does not include periodic verification testing, but does have provisions for unannounced inspections of participating manufacturer's production facilities to look for changes in certified model design or construction. The existence of this industry program increases the likelihood that energy efficiency representations of covered boilers are accurate, at least for participating manufacturers. HI claims that over

ninety percent of the cast iron and copper fin boiler manufacturers participate in their certification program. The manufacturers of large steel boilers do not participate in the HI certification program, but rather test according to the American Boiler Manufacturers Association (ABMA) procedures. Furthermore, the manufacturers maintain that the HI program is effectively policing the marketplace, and thus any additional testing and certification requirements are unnecessary.

- For commercial water heaters, the program is operated by the Gas Appliance Manufacturers Association (GAMA). This is a voluntary program that allows participating manufacturers to certify the performance of their equipment, and which conducts periodic verification testing of performance claims. Equipment performance values are listed in a directory that is available to the public. The existence of this industry program increases the likelihood that energy efficiency representations of covered water heaters are accurate, at least for participating manufacturers. GAMA claims that about two thirds of the commercial water heater manufacturers participate in the voluntary certification program.
- There is currently no industry certification program for furnaces.

Due to the above considerations, NIST recommends that DOE minimize additional testing burdens on manufacturers of commercial HVAC and water heating equipment, while maintaining a certification procedure which is both fair to all manufacturers, and which will provide a reasonable assurance that the established minimum performance standards are being met. The proposed procedures are described in the following sections, and include a basic certification program, a provision for voluntary independent certification program, and an enforcement testing plan. This proposal would not require any additional testing not already being conducted by manufacturers who are participating in an industry certification program, and would involve a similar level of testing by manufacturers not participating in that or another equivalent industry certification program.

4.1.2 Certification Procedures

NIST recommends that DOE adopt a certification plan for commercial equipment which incorporates the determination of efficiency based on testing conducted by or for the manufacturer and reported to DOE, either directly or through a designated industry organization. The value for efficiency shall be that which the manufacturer determines to be the mean for all of the units of that basic model, using any valid statistical method, and shall be based on the results of testing in accordance with the applicable test procedure. The individual units tested shall be representative of the basic model, and a sufficient number shall be tested to ensure that an accurate estimate of the mean efficiency of the basic model can be determined. The number of units to be tested, and the method for determining the mean efficiency are left to the discretion of the manufacturer, however all test results and related analysis used in the determination of the mean must be maintained by the manufacturer as a permanent record. A possible format for certifying the efficiency to an authorized trade association or to DOE is included in Appendix A.

4.1.3 Alternative Methods for Determining Efficiency

NIST recommends allowing the determination of efficiency based on testing results while not specifically requiring actual testing of every basic model, due to the potentially large number of basic model variations and the subsequent large testing burden. Thus, the efficiency of a basic model could be determined using analytical procedures such as computer simulation or other approaches, as long as those procedures have been verified and validated using testing results. Written documentation demonstrating the validation of such analytical procedures must be maintained as a permanent record, and must be approved by a registered professional engineer, independent of the company.

4.1.4 Voluntary Independent Certification Program

Manufacturers who participate in industry rating and certification programs have their equipment subjected to periodic verification testing, which is conducted at independent laboratories, or by independent testing personnel. This provides a strong deterrent to false performance claims. However, manufacturers who do not choose to participate in an industry rating program are not subject to verification testing. Thus, NIST recommends that manufacturers participating in industry certification programs which meet the following requirements would be able to demonstrate compliance through their participation in the industry certification program.

Manufacturers not participating in voluntary industry certification programs would have to have their covered products tested at an independent laboratory, or meet stricter compliance certification criteria.

<u>Requirements for Approved Voluntary Independent Certification Programs</u>

(1) Energy efficiency performance metrics must be based on measurements.

(2) Testing must be conducted at an independent laboratory, or under the supervision of independent personnel, in accordance with the prescribed DOE test procedures.

(3) Periodic verification testing must be conducted on listed equipment, such that the performance of each basic model is checked at least every five years.

(4) Equipment which fails verification testing must either be removed from production and sale, or be delisted.

(5) Units selected for verification testing must be selected randomly from manufacturer's stock.

(6) The procedures for the operation of the certification program must be published in written form.

Voluntary Independent Certification Programs which meet the above requirements can request DOE approval by submitting documentation substantiating their compliance directly to DOE.

For manufacturers of covered commercial HVAC and water heating products who do not participate in a DOE approved Voluntary Independent Certification Program, the performance of covered products must be determined by measurements conducted at an independent laboratory, or under the supervision of independent personnel, or the representations must be reviewed and certified by an independent state-registered professional engineer who is not an employee of the manufacturer. The registered professional engineer is to certify that the representation accurately reflects the energy efficiency of the covered product. The following sampling procedure must be followed:

A sample of sufficient size shall be tested to ensure that

- any represented value of energy efficiency shall be no greater than the lower of (A) the mean of the sample, or (B) the lower 95 percent confidence limit of the true mean divided by 0.95, or,
- any represented value of energy usage shall be no less than the greater of (A) the mean of the sample, or (B) the upper 95 percent confidence limit of the true mean divided by 1.05.

4.1.5 Enforcement Procedures

NIST recommends keeping essentially the same enforcement regulations for commercial HVAC & water heating equipment as currently in place for the covered residential appliances. The only exceptions would be special provisions for covered equipment which are manufactured in very small quantities, or which are very large in size. Current enforcement regulations require the testing of a minimum of four units, with the potential for the testing of up to twenty units. This would be impossible for basic models manufactured in small quantities, and prohibitively expensive for extremely large basic models. Thus, NIST recommends that if the total number of available units of a basic model involved in an enforcement action is less than four, then all of the units shall be tested. An exception could be made available for very large units on a case-by-case basis, such that only a single unit would be tested.

4.1.6 Proposed Sampling Scheme for Enforcement Testing

NIST recommends a sampling scheme for the enforcement testing of commercial equipment, as outlined in Appendix B.

4.2 Test Protocols for Commercial Water Heaters and Unfired Hot Water Storage Tanks

4.2.1 General Discussions

This subsection discusses the main issues identified for test procedures for commercial water heaters and commercial unfired hot water storage tanks.

4.2.2 Commercial Water Heater Test Procedure

NIST's proposed amendments to the water heater test procedure include incorporation by reference portions of ANSI Z21.10.3-1993 that pertain to the measurement of thermal efficiency and standby loss. NIST also proposes modifications of the procedure to maintain consistency with the test procedure upon which federal energy conservation standards are based and to provide specifications for the measurement equipment to be used to perform the tests.

EPAct indicates that "test procedures shall be those generally accepted industry testing procedures or rating procedures developed or recognized by the Air-conditioning and Refrigeration Institute or by the American Society of Heating, Refrigerating and Air Conditioning Engineers, as referenced in ASHRAE/IES Standard 90.1 and in effect on June 30, 1992."ASHRAE/IES Standard 90.1-1989 with Addendum b was in effect on this date and the referenced test procedure for commercial water heaters was ANSI Z21.10.3-1990. Since then Addendum 90.1n-1997, which is related to commercial water heating equipment, was approved by ASHRAE. Addendum n references ANSI Z21.10.3-1993. Portions of ANSI Z21.10.3-1993 related to thermal efficiency and standby loss testing, as referenced within the test procedure being set forth in Appendix F, were unchanged from 1990 to 1993.

There are two other currently published test procedures that have been considered for incorporation by reference, ANSI Z21.10.3-1998 and ASHRAE 118.1-1993. ANSI Z21.10.3-1998 was published in April 1998. This version contains changes in the Method of Test sections of both the thermal efficiency and standby loss test procedures. These changes include differences in test setup procedures as well as reducing the test duration of the standby loss test from 48 to 24 hours. The ASHRAE test procedure also contains differences in test setup requirements from those of ANSI Z21.10.3-1990/93 as well as the shortened 24 hour standby loss test duration. Although these test procedures are fundamentally similar to procedures contained in ANSI Z21.10.3-1993, they are not being incorporated by reference at this time because there is not sufficient evidence to indicate whether these changes will affect energy conservation standards for covered equipment.

It is recommended that ANSI Z21.10.3-1993 be adopted as the test procedure for water heaters. NIST believes that incorporation of ANSI Z21.10.3-1993 would not alter the energy standards for water heaters currently in place. Comments are requested on the impact of selecting this test procedure for incorporation by reference. Strong consideration was given by NIST to recommending the incorporation of ASHRAE Standard 118.1-1993. However, after carefully reviewing the document, it was determined that modifications would have to be provided to bring certain portions of the test procedure in line with the test procedures contained in ANSI Z21.10.3-1993 so as not to affect energy standards. Consideration was also given to the fact that

ASHRAE 118.1-1993 is currently undergoing revisions as is ASHRAE Standard 90.1-1989. When the revised Standard 90.1 is approved, the Department is required to review the impact on energy standards of the revised/amended standard. Upon amendment of Standard 90.1-1989, the Department can reconsider incorporation of the test procedure referenced by the revised Standard 90.1.

Measurement Equipment Specifications

Specifications for measurement equipment to be used to conduct thermal efficiency and standby loss tests are not included in ANSI Z21.10.3-1993. These specifications should be included to maintain consistency among test facilities. The specifications that will be provided within Appendix F to Subpart B of Title 10 CFR Part 431 will be as contained in the Instrumentation subsection of Appendix E to Subpart B of 10 CFR Part 430 for temperature, pressure, higher heating value, weight, combustion products, energy consumption and rate of energy consumption.

Oil-fueled Water Heaters

ANSI Z21.10.3-1993 does not address the testing of oil-fueled water heaters (since it is limited to natural gas). Therefore, provisions are added to allow ANSI Z21.10.3-1993 to directly address the testing of oil-fueled water heaters. These modifications are the same as those provided as a footnote to Table 11.1 of ASHRAE Standard 90.1-1989 Addendum n.

Electric Water Heaters

ANSI Z21.10.3-1993 does not directly address the testing of electric water heaters. Therefore, provisions are added to allow the ANSI test procedure to directly address the testing of electric water heaters. These modifications are the same as those provided as a footnote to Table 11.1 of ASHRAE Standard 90.1-1989 Addendum n.

Hot Water Supply Boilers

Hot water supply boilers are designed and marketed to provide service water heating. Addendum n to ASHRAE Standard 90.1-1989 requires hot water supply boilers to meet the same energy efficiency requirements as water heaters. NIST recommends that the Department consider adoption of the ASHRAE approach related to commercial hot water supply boilers, requiring hot water supply boilers to meet the energy efficiency standards for commercial water heaters.

Instantaneous Water Heater Definition

The definition of commercial instantaneous water heaters contained in EPAct and the definition of consumer water heaters contained in NAECA do not specifically address devices that are designed to heat water to temperatures of 180°F or higher. At the Workshop on Commercial Appliances in April of 1998 GAMA stated that these devices are not designed or marketed to be used in consumer/residential applications regardless of the input ratings of the devices and therefore should be subjected to the energy conservation standards of commercial equipment. This would be consistent with the definitions of instantaneous water heaters presented in Appendix E to Subpart B of 10 CFR Part 430 which exclude water heaters designed to deliver water at a controlled temperature of 180°F or higher. Also, the Public Review Draft of ASHRAE

Standard 90.1-1989R indicates that instantaneous water heaters designed to heat water to temperatures of 180°F or higher must meet commercial product energy performance criteria regardless of input rating. The Department is considering whether instantaneous water heaters designed to heat water to temperatures of 180°F or higher should be subjected to the energy conservation standards of commercial equipment regardless of input rating. The Department is reviewing its statutory authority to determine whether products that are covered by the NAECA standards can be required to meet EPAct energy conservation standards. The rationale is that product design and the intended use of such products may clearly indicate whether they are commercial or residential products.

Based on EPAct definitions, the input rating for an EPAct-covered commercial water heater must lie above a minimum value, which corresponds to the upper limit for the NAECA-covered water heater input rating. There are no size limits based on storage volume in either NAECA or EPAct. However, the DOE test procedure for residential water heaters (Appendix E to Subpart B of 10 CFR Part 430) does not apply to instantaneous water heaters with storage volumes greater than or equal to 2 gallons. This causes a gap in test procedure coverage for instantaneous water heaters which fall under NAECA coverage based on input rating but have storage volumes of 2 gallons or more. At the Workshop on Commercial Appliances in April of 1998, GAMA and A. O. Smith pointed out this gap in coverage. They also stated that these equipment are not designed or marketed as consumer products. For the reasons given above, the Department is considering whether instantaneous water heaters having storage volumes of 2 gallons or more should be subjected to the energy conservation standards of commercial equipment regardless of input rating.

Exemption from Standby Loss Testing

The exemption from standby loss testing may be claimed if the water heater has a storage capacity greater than 140 gallons, the tank surface area is insulated to R-12.5 and the water heater does not have a standing pilot light. In order to clarify the requirements for claiming the exemption, the definitions of R-value and tank surface area are presented in the test procedure. R-value is defined as it relates to standard methods for its determination, and tank surface area is defined in terms of what portions shall be insulated to meet the exemption criterion. The Department is considering approaches that would strengthen building code inspection and verification of compliance with these provisions.

4.2.3 Commercial Unfired Storage Tank Test Procedure

Measurement of Heat Loss

EPAct sets forth requirements for a maximum heat loss rate of 6.5 Btu/h per square foot of tank surface area for certain unfired storage tanks. EPAct indicates that "test procedures shall be those generally accepted industry testing procedures or rating procedures developed or recognized by the Air-conditioning and Refrigeration Institute or by the American Society of Heating, Refrigerating and Air Conditioning Engineers, as referenced in ASHRAE/IES Standard 90.1 and in effect on June 30, 1992." However, there is currently no test procedure referenced in ASHRAE Standard 90.1-1989, including addenda, for this category of equipment. Therefore, NIST has developed a procedure for testing unfired hot water storage tanks. This test procedure consists of two methods for determining the rate of heat loss per square foot of tank surface area. The first method involves performing the standby loss test procedure on an electric storage water heater utilizing an identical tank with identical insulation and jacketing as that of the unfired storage tank model and performing the necessary calculations to determine heat loss per square foot of tank surface area. This procedure will enable the determination of heat loss of an unfired storage tank as well as the standby loss of an electric storage water heater utilizing the same tank and insulation (having a thermal resistance no greater than that used on the unfired device). The second method is generally applicable to unfired hot water storage tanks. It utilizes a separate water heater connected to the unfired storage tank to charge the storage tank before and after a standby loss test period. The first method of testing is preferred and is meant to be less burdensome on manufacturers by utilizing the test data of a storage water heater to determine the heat loss of the unfired storage tank and the standby loss of the storage water heater if the storage water heater is constructed the same way as the unfired storage tank.

Exemption from Heat Loss Testing

The exemption from heat loss testing may be claimed if an unfired hot water storage tank has a storage capacity greater than 140 gallons and the tank surface area is insulated to R-12.5. In order to clarify the requirements for claiming the exemption, the definitions of R-value and tank surface area are presented in the test procedure. R-value is defined as it relates to standard methods for its determination, and tank surface area is defined in terms of what portions shall be insulated to meet the exemption criterion. The Department is considering approaches that would strengthen building code inspection and verification of compliance with these provisions.

4.2.4 Proposed Test Procedures for Commercial Water Heaters

NIST recommends a test procedure for measurement of the energy consumption and energy efficiency of commercial water heaters, as outlined in Appendix C. The recommended test procedure for unfired hot water storage tanks is listed in Appendix D.

4.3 Test Protocols for Commercial "Packaged" Boilers

4.3.1 General Discussions

ASHRAE 90.1 Referenced Test Standards

EPCA requires that the testing procedures for measuring the efficiency of commercial packaged boilers shall be those generally accepted industry testing procedures or rating procedures developed or recognized by the American Society of Heating, Refrigerating and Air Conditioning Engineers, as referenced in ASHRAE/IES Standard 90.1 and in effect on June 30, 1992. If such an industry test procedure or rating procedure for commercial packaged boilers is amended, DOE shall adopt such revisions unless the Secretary determines that to do so would not produce test results which reflect energy efficiency, energy use, and estimated operating costs, and would be burdensome to conduct.

As referenced in ASHRAE 90.1 and in effect on June 30, 1992, there are five industry test standards for gas and/or oil fired boilers. They are the American National Standard Institute ANSI Z21.13-1987 for gas fired boilers (ANSI Z21.13); the Hydronics Institute Testing and Rating Standard for Heating Boilers-1989, sixth edition, for gas and oil fired boilers (abbreviated as HI Std.); the American Society of Mechanical Engineers Power Test Code 4.1-64 (reaffirmed R79/85/91) for Steam Generating Units for fossil fuel boilers (ASME PTC 4.1); the Underwriters Laboratory Standard 795-1973 for gas heating equipment (UL 795); and Underwriters Laboratory Standard UL 726-1990 for oil fired boilers (UL 726). Of the five test standards, four are applicable to gas fired boilers and three are applicable to oil fired boilers.

Since the year 1989, three of the industry test standards have been revised. ANSI Z21.13-1987 was first revised to ANSI Z21.13-1991, and ANSI Z21.13-1991 was further revised via Addenda Z21.13a-1993 and Z21.13b-1994; UL 795-1973 was revised to UL 795-1994; and UL 726-1990 was revised to UL 726-1995. Also, ASHRAE 90.1-1989 itself was revised via Addenda 90.1b, 90.1d, and 90.1e in 1992, 90.1c, 90.1g, and 90.1i in 1993, and 90.1m-1995 and 90.1n-1997. Currently, a revision to ASHRAE 90.1-1989, named ASHRAE 90.1-1989R, is going through the ASHRAE public review process.

Of the three industry test standards revised after June 30, 1992, there is no change in the energy performance test sections of UL 795 and UL 726 from their prior versions. There are changes in the efficiency test section of ANSI Z21.13 between the Z21.13-1991 (and the early 1987 versions) and the Z21.13-1993a versions. The major changes are (1) the title of the section (sec.2.11) for efficiency testing was changed from "Thermal Efficiency" to "Efficiency", (2) the requirement for efficiency rating was changed from "not less than that specified by the manufacturer" to "not less than 98% of that specified by the manufacturer", (3) the result efficiency rating (value) was changed from "rounded to the lower integer (dropping the fraction after the decimal point)" to "rounded to the nearest 0.1 percent", (4) inlet water temperature for both steam boiler test and hot water boiler test was changed from "not specified" to "80 ±10°F", and (5) thermal efficiency test for steam boilers for outdoor installation was dropped in the 1993a version. Of the five changes, item 1 eliminated the confusion in efficiency terminology where the resulting combustion efficiency for indoor boilers was called thermal efficiency in the 1991 version. Item 2 presumably was to provide a tolerance of 2% due to the variability of test results between of two independent tests (manufacturer's and testing agency's). Item 3 was to give the test boiler a more accurate representation for the efficiency value (since the fractional value can get rounded down by as much as 0.9%). Item 4 was to provide a more repeatable test result by eliminating the ambiguity of a un-specified test water inlet temperature. The reason for the change in item 5 is not clear. Of the five revisions, the specification of inlet water temperature (item 4) and the elimination of test for steam boilers for outdoor installation (item 5) are directly related to test procedure change. The inlet water temperature specification of $80 \pm 10^{\circ}$F would provide more repeatable test results and is in agreement with the requirement for "Combustion Test" specified in section 2.6.1 of both versions (1987 and 1993a) of the standard. Since EPCA specifies combustion efficiency as the energy efficiency descriptor for all commercial packaged boilers, the test for thermal efficiency for a steam boiler is not required by the statute at the present time. Based on the above discussion, NIST believes that the revisions contained in ANSI Z21.13-1993a would not produce results that reflect on energy efficiency and would not be unduly burdensome to conduct.

Definition and Boiler Capacity

EPAct defines a packaged boiler as "a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections." EPAct, Sec.122(a)(11)(B). Of the five test standards (procedures) for commercial heating boilers referenced by ASHRAE 90.1-1989 which in turn was referenced by EPAct, and in effect on June 30, 1992, three provided similar definitions for packaged boilers, one implied that the boiler under its scope to be a packaged boiler by limiting the size of the boiler covered, and one provided no definition. Specifically, the Hydronics Institute's "Testing and rating Standard for Heating Boilers - 1989" (abbreviated as HI -1989) defines a packaged boiler as "a boiler-burner unit factory assembled and wired". HI does not specifically limit the test standard to commercial packaged boilers. However, HI limits the test standard to low-pressure heating boilers as defined in ASME Boiler and Pressure Vessel Code, Section IV, Heating Boilers. The Underwriters Laboratory's UL 726 for "Oil-Fired Boiler Assemblies" defines an oil-fired boiler assembly as "A boiler assembly equipped with one or more oil burners, and all the necessary safety controls, electrical equipment as needed, and related equipment, manufactured for assembly as a unit". UL 795 for "Commercial-Industrial Gas Heating Equipment" including gas-fired boilers defined a term "gas-fired device" as ".... each device shall be factory-built and shall include all essential components necessary for its normal function as intended, and may be shipped as two or more major subassemblies". In addition, both UL 726 and UL 795 specify that "...each subassembly shall be capable of being incorporated into the final assembly without requiring alteration, cutting, drilling, threading, welding or similar tasks by the installer. ..." Both UL 726 and UL 795 limit the scope of coverage to a boiler assembly. ANSI Standard Z21.13 does not define a term for commercial packaged boilers, however, the standard limits its scope of coverage to gas-fired low-pressure steam and hot water boilers with input ratings of less than 12,500,000 Btu/h that likely would limit its coverage to commercial packaged boilers as defined in EPAct. The fifth referenced standard, the ASME Power Testing Code for Steam Generating Units, ASME PTC 4.1, provides no definition for a packaged boiler.

During the April 1998 DOE workshop, the meaning of a packaged boiler with respect to capacity (size), method of shipment and assembly, types (low-pressure steam and hot water heating boilers, high temperature hot water boilers, and high-pressure steam power boilers) and application (space heating, service water heating, industrial and utility applications) were discussed. The Gas Appliances Manufacturers Association (GAMA), the American Boilers Manufacturers Association (ABMA) and Council of Industrial Boiler Owners (CIBO) commented that even though there was no clear-cut criteria on what constitutes a packaged boiler, in general a boiler will not be classified as a packaged boiler if field (at the site) welding, pressure parts, or fabricating the assembly at the site are required. The criterion of using the size or rated input and/or output capacity as a possible factor in the definition for commercial packaged boilers was discussed and suggested by some attendees as helpful in defining the scope of coverage in a DOE test procedure for commercial packaged boilers. As described in the previous paragraph, ANSI Z21.13 limits its coverage of boilers to low-pressure steam and hot water boilers of less than 12,500,000 Btu/h input. A survey of the commercial boilers in the 1998 certified rating directory of the Hydronics Institute showed the largest capacity (output) boiler to be a gas fired heating boiler with approximately 14,000,000 Btu/h gross output. Therefore, there is reason to believe that there is a current practice of producing, in quantities, packaged low-pressure steam and hot water heating boilers with output capacity of up to approximately 14 million Btu per hour. However, the California Energy Commission (CEC) pointed out that the statute does not provide an upper limit on capacity in its definition for commercial packaged boilers. Therefore CEC stated that one cannot specify an upper limit on capacity in a DOE test procedure for commercial packaged boilers. NIST agrees with CEC's comment that the statute does not specifically provide an upper limit to the capacity of a packaged boiler. Therefore, the setting of an upper limit on the capacity of a packaged boiler is not recommended in the proposed test procedure.

NIST realizes that even though there are packaged heating boilers, especially of the steel fire tube or water tube design, that have capacities greater than those covered by the ANSI Z21.13 standard of 12,500,000 Btu/h, the limited quantities produced and the method of marketing those boilers (such as custom made to order with provision for acceptance test to verify efficiency guarantee) may make the testing to conform to a DOE test procedure impractical or un-necessary. Therefore, input and comments are sought from all stakeholders on the appropriateness and practicality (with respect to application and quantity produced) on the setting of an upper limit on capacity, and if appropriate, on the value of the upper limit.

NIST believes that the definition of a packaged boiler is clear enough to exclude custom-design (for a specific installation), field-constructed (as opposed to a re-assembly of major sub-assemblies disassembled for shipping purpose) boiler system, and no additional clarification is needed to the definition of commercial packaged boilers as stated in the statute.

In its comment, CEC recommended that an "editorial" change be made to the EPAct definition of packaged boiler by deleting the word "usually" in the definition. CEC suggested that the word "usually" in the definition could imply that a packaged boiler can be shipped in less than one package. NIST believes that nothing would be gained by deleting the word "usually" even if it appears redundant. And, if "usually" refers to the word "sections", instead of the number of them, some meaning might be lost by deleting it. Therefore, NIST is not adopting for recommendation

CEC's suggestion of deleting the word "usually" in the definition for commercial packaged boilers.

Scope of Coverage

In Addendum 90.1n to ASHRAE Standard 90.1-1989, a boiler is defined as "a self-contained appliance for supplying steam or hot water". ANSI Standard Z21.13 defines a gas-fired boiler in the same way as ASHRAE Addendum 90.1n. The Hydronics Institute's Testing and Rating Standard for Heating Boilers (HI Standard - 1989) defines a boiler as "a closed direct fired pressure vessel intended for use in heating water or generating steam to be used external to itself". Both UL Standards 726 and 795 define a boiler as "a closed vessel in which water or some other liquid is heated or steam is generated or superheated, under pressure or vacuum, by direct application of heat". ASME PTC 4.1 defines "a steam generating unit (including the boiler, furnace, superheater, reheater ... and fuel-burning equipment) as combinations of apparatus for liberating and recovering heat, together with apparatus for transferring to a working fluid the heat thus made available". In all these definitions, there is no explicit language on the type of applications, that is, space heating, industrial process heating, power generation, etc. that the test boiler is to be used, except that in their Scope sections, ANSI Z21.13 and HI Standard - 1989 limit the class of boilers to low-pressure steam and hot water heating boilers.

During the April 1998 workshop, questions were raised as to the scope of coverage in a DOE test procedure with respect to the end use of a packaged boiler since the statute does not explicitly specify the type of applications where the term "packaged boiler" is involved. It was pointed out by CIBO, and others that the hot water and steam produced by a packaged boiler can be used for process heating in industrial and manufacturing processes where, in addition to efficiency, other (design) considerations may be involved in the operation of a boiler. ABMA and CIBO also pointed out that there are packaged high-pressure steam and high temperature hot water boilers that are different from the low-pressure steam and hot water heating boilers (as classified by ASME) usually used in space heating and service water heating applications. Other attendees (GAMA, Lennox International) pointed out that EPAct invokes ASHRAE 90.1 for the test procedures in the energy efficiency testing of commercial equipment, and that historically ASHRAE 90.1 specified the equipment covered in the standard to space conditioning and service water heating applications only. Lennox also stated that it believed that the intent of EPAct when it was developed was to have the equipment test standards to come forth from ASHRAE 90.1, and those applications other than space conditioning and service water heating were not within the scope of ASHRAE 90.1. The above arguments are relevant in view of the fact that the EPAct efficiency standard levels also appear in ASHRAE 90.1.

A review of the scope of ASHRAE 90.1 and the five test standards referenced by ASHRAE 90.1 for testing boilers showed the following:

ASHRAE 90.1: By its title, "Energy Efficiency Design of New Buildings except Low-Rise Residential Buildings", the standard indicates that it is concerned with minimizing the energy consumption in the operation and maintenance of the building itself (that is, energy consumption with respect to the function of the building and the comfort of the occupants). In ASHRAE 90.1-1989, there was no specific language excluding the coverage of certain types of equipment that are installed in the building. However, in a revision in July 3, 1997 to the standard with respect to the Title, Purpose, and Scope (TPS) of the standard by the ASHRAE Standing Standard Project Committee 90.1 (SSPC 90.1), the scope was revised to exclude from coverage "equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing or commercial processes".

HI Standard (1989) (for oil or gas-fired boilers): Limits its scope to boilers conforming to ASME Boilers and Pressure Vessels Code, Section IV, Heating Boilers. Therefore, the test standard is limited to 15 psig maximum steam pressure for steam heating boilers and to 160 psig, 250°F water for hot water boilers.

ANSI/AGA Z21.13 (for gas -fired boilers): Limits its scope to boilers with 15 psig maximum steam pressure for steam heating boilers and 160 psig, water pressure, 250°F water temperature for hot water heating boilers with a input rating of less than 12,500,000 Btu/h.

UL 726 (for oil-fired boilers): No limit is placed on steam pressure or on hot water temperature. The test standard is limited to boiler assemblies as defined in the standard.

UL 795 (for gas-fired boilers): No limit is placed on steam pressure or on hot water temperature. The test standard is limited to boiler assemblies defined in the standard.

ASME PTC 4.1 (for Fossil-fueled steam boilers): No limit is placed on steam pressure or capacity. The test standard is limited to steam boilers (steam generating units) but also applicable to high temperature (above 250°F water temperature) hot water boilers.

In reviewing the above industry standards that are referenced by EPAct (or referenced by EPAct via ASHRAE 90.1), it is believed that the intent of ASHRAE 90.1, HI Standard -1989 and ANSI Z21.13 is to cover low-pressure steam and hot water heating boilers designed for space conditioning and service water heating purposes. The intent of the two UL standards is testing for safety certification (with respect to construction and operation) where the performance tests are specified to insure that the test boiler will perform to some minimum level of its intended function. The intent of ASME PTC 4.1 is mainly for the acceptance test of large steam generating units where a detailed account of all energy expenditures is desired. This is evident by the detailed heat gain and heat loss measurement and calculation procedures specified in the test codes for all components of the boiler system. However, the standard does provide for an abbreviated (simplified) efficiency test for the acceptance test of small heating and industrial steam generators.

A review of the relevant sections of EPAct indicated that even though the statute does not restrict the coverage of commercial packaged boilers to space conditioning and service water heating, the amendment to Sec.340 of EPCA (42 U.S.C.6311) as contained in EPAct did put commercial packaged boilers and warm air furnaces (which is for space heating use only) into a single item (EPAct, sec.122(a)(1)(B)(E)), and inserted the item into the midst of the definitions for other added/amended items (from small commercial packaged air conditioning and heating equipment to storage water heaters, ..., all of which are equipment exclusively, for space conditioning and service water heating purposes). EPAct, sec.122(a)(1)(B). In addition, in EPCA (EPCA, sec.340(2)(B), 42 U.S.C.6311), an item for "steam boilers (clause ix)" was included as a separate item, and has been retained in EPAct as a redesignated clause viii. EPAct, sec.122(a)(2)(B). NIST believes that the intent of the statute is to designate the term "packaged boiler" as an ASME heating boiler (a low-pressure steam and hot water heating boiler) used for space conditioning (and service water heating) for the purpose of coverage, and designate the term "steam boilers" for more general applications such as industrial processes and power generation. It is noted that the statute does not provide a definition for steam boilers referred to in clause viii (EPAct, sec.122(a)(2)(B)(viii)) or establish an energy efficiency standard for steam boilers.

Based on the above discussion, NIST agrees with the majority of the comments from the workshop that the coverage in a DOE test procedure for commercial packaged boilers be limited to ASME heating boilers for space conditioning (and service water heating as in hot water supply boilers) only. Therefore, it is proposed that at the present time, the scope of the DOE test procedure for commercial packaged boilers should be limited to low-pressure steam and hot water heating boilers only. Input and comments are requested on the appropriateness of this proposal from all interested stakeholders before a final decision is reached.

For the purpose of discussion, it is also relevant to take note of a decision made recently during an ASHRAE 90.1 September meeting in Chicago, which resulted in the adoption of an 8,000,000 Btu/hr limit on non-packaged boilers as equipment covered by the standards. The proposed wording states:

> These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

The proposed definitions for boiler and packaged boiler for ASHRAE 90.1-1989R, were also modified at the same ASHRAE meeting as follows:

> *Packaged Boiler*- a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; shipped in one or more sections. Packaged boiler includes factory built boilers manufactured as a unit or system, disassembled for shipment and reassembled at the site.
>
> *Boiler*- a self contained low-pressure appliance for supplying steam or hot water.

The proposed ASHRAE wording may address some of the concerns raised by the ABMA during the April 1998 workshop. However, it should be pointed out that the proposed limit on rated input of 8,000,000 Btu/h or less does not apply to packaged boilers which will be covered by the proposed DOE test procedure.

4.3.2 Test Procedures for Measurement of Energy Efficiency

<u>Uniformity in Test Setup and Test Conditions for a Uniform DOE Test Procedure</u>

As described and listed above, ASHRAE 90.1 referenced five industry test standards for the testing of gas and oil fired boilers. Four of the test standards can be applied to gas-fired boilers and three of them can be applied to oil fired boilers. Out of the five, two of them are for both gas fired and oil fired boilers. Specifically:

- ANSI/AGA Z21.13 is for gas fired boiler and limits the size of the test boiler to 12,500,000 Btu/h. The 1991 version of the standard set the outlet water temperature to 180°F without specifying an inlet test temperature (a value of 80 ±10°F, however, is set in its Combustion Test section). A revision of the standard in 1993 (ANSI Z21.13a) set the inlet temperature to 80°F ±10°F.
- UL 726 and UL 795 do not provide a calculation procedure for the flue loss. They specify an inlet test temperature of 20°F below the outlet water temperature while limit the outlet temperature to no less than 200°F.
- ASME PTC 4.1 is for steam and high temperature water boilers only.
- HI-1989 is applicable to both gas and oil fired boilers. However, HI specifies a test condition that results in a wide range of test inlet water temperature, ranging from 35°F to 80°F. With the outlet water temperature specified at 200°F, this could create a situation where, depending on test inlet temperature, two different efficiency values could be obtained and both would be valid.

From the above list, it is seen that for gas-fired boilers, there are differences between the ANSI Z21.13 standard and the UL 795 and HI-1989 standards in the setting of both inlet and outlet water temperatures for hot water boilers. The specification in the 1993 version of the ANSI Z21.13-1993a is more precise. In its comments, CEC recommended that the HI-1989 test standard be adopted by DOE as the test standard for both gas-fired and oil-fired boilers. The revised ASHRAE 90.1 under public review also specifies the HI-1989 as the primary test standard for both gas and oil fired boilers, however, in a footnote, it listed as an option the ANSI Z21.13 for boilers with input of less than 2,500,000 Btu/h and ASME PTC 4.1 for boilers with input greater than 5,000,000 Btu/h.

As stated in the above list, both gas and oil fired boilers are covered in the HI-1989 standard. However, in its Scope section, HI states that for a gas-fired boiler, its coverage is based on test reports from the AGA and CGA Laboratories which complied with ANSI Z21.13, which currently is the updated Z21.13-1993a. Except the water inlet and outlet conditions for hot water boilers, the test setup, instrumentation, etc. in the HI-1989 standard and Z21.13 are very similar. The one difference in the test setup is that the HI-1989 standard requires insulation of the test stack to the point of flue gas temperature measurement while the Z21.13 standard does not require any insulation. This would result in a higher combustion efficiency (lower calculated flue loss based on flue gas temperature) from the ANSI/AGA Z21.13 procedure than the HI-1989 procedure, if all other test conditions are the same.

As stated before, the HI test standard allows a wide range of test inlet water temperatures. The reason for this is that in the certification program, the boilers are tested at the manufacturer's plant, not at the Hydronics Institute. Depending on the season and the manufacturer's geographical location, the inlet water temperature from the water main (or other source) can vary widely. During the April 1998 workshop, GAMA stated that the difference in combustion efficiency due to the variation of inlet temperature might be small.

Based on the above discussion, it is seen that even though there might be some difference in the test conditions between HI-1989 and ANSI Z21.13, the attendees of the April 1998 workshop suggested that the HI test standard be used to cover both gas fired and oil fired boilers. NIST recommends that the HI-1989 standard be used for both gas and oil fired low-pressure steam and hot water boilers with a revised inlet and outlet water temperatures of 80 ±10°F and 180 ±2°F, respectively, conforming to the requirement of ANSI Z21.13-1993a. The practical problem of testing a large hot water boiler with a large required water flow rate at a controlled inlet water temperature may need the pre-conditioning of the inlet water temperature in some regions of the country. However, it is observed that the procedure as specified in ANSI Z21.13-1993a has been in practice since 1993, indicating that this may not be a major problem for a boiler of less than 12,500,000 Btu/h rated input. The difference in the required outlet temperature for hot water boilers, of 200°F by HI standard and 180°F by ANSI Z21.13, may produce a slight increase in the combustion efficiency rating of a boiler currently rated using the HI standard due to a possibly lower flue gas temperature. However, it is believed that this increase is small and will have no effect on the minimum standard rating specified by EPAct.

Of the other three test standards referenced in ASHRAE 90.1-1989, the ASME PTC 4.1 standard is for (large) steam generating heating and power boilers requiring a detailed account of the energy expenditures of all components in the boiler system which would be burdensome to conduct for smaller capacity boilers. The HI standard appears to be an adequate substitute for the ASME PTC 4.1 with respect to low-pressure steam boilers since the test and calculation procedure in the HI standard is close to the simplified efficiency test (or the abbreviated efficiency test) of ASME PTC 4.1. The two UL standards (UL 726 and UL795) are mainly test standards for safety certification testing of boilers. The test procedures in the UL standards are similar to the HI-1989 standard except the UL standards specify an inlet water temperature of nominal 200°F for hot water boilers. In addition, the UL standards do not provide a calculation procedure for the flue loss computation. In NIST's opinion, the HI-1989 standard is an adequate substitute for the two UL standards in the area of performance testing for energy efficiency of low-pressure steam and hot water boilers.

Based on the above discussion, NIST recommends that the HI-1989 standard be referenced as a single uniform DOE test standard for commercial, packaged, gas and oil fired, low-pressure steam and hot water boilers for space heating application, with the provision that the inlet water temperature for hot water boilers be specified at 80 ±10°F and the outlet water temperature for hot water boilers be set at 180 ±2°F. Comments are being sought from all stakeholders on this recommendation, including the applicability of the specified setting of inlet water temperature for hot water boilers.

For packaged high-pressure steam and high temperature hot water boilers, the only detailed test procedure for energy efficiency testing is ASME PTC 4.1. As discussed earlier, during an ASHRAE 90.1 Mechanical subcommittee meeting in Chicago (held September 9-12, 1998) the definitions of the terms for boiler and packaged boiler were modified so that a boiler was defined as a self contained low-pressure appliance for supplying steam or hot water. Therefore, NIST recommends that high-pressure packaged boilers not be considered as covered equipment at this time.

Provisions for Low Temperature Applications

The issue of a hot water boiler designed for low temperature applications (supply water of 140°F or return water temperature of 120°F, or below) was raised and discussed during the April 1998 workshop. ASHRAE 90.1 and the test standards referenced by ASHRAE 90.1 do not specifically provide test conditions for testing this type of application, since this type of boiler, which is designed to be used only in the low temperature range, may not be yet on the market, the comments of the attendees to the workshop were that it was not necessary for DOE to develop another set of test conditions deviating from the test conditions specified in the ASHRAE 90.1 referenced test standards at the present time. That is, special provisions to specify a lower hot water outlet temperature different from that specified in the referenced test standards (of 180°F or 200°F) are not needed. NIST agrees with the attendees' comments and does not recommend a different set of test inlet and outlet water temperatures for this type of applications that require a low supply and return temperature setting.

Provision for Condensing Boilers

The issue of testing a condensing boiler (a hot water boiler designed to condense part of the water vapor in the flue gases and equipped with a means of collecting and draining this condensate) was raised and discussed during the DOE April 1998 workshop. ASHRAE 90.1 and the test standards referenced by ASHRAE 90.1 do not specifically provide test conditions for testing a condensing boiler. Further, since commercial condensing boilers may not be on the market, the comments of the attendees to the workshop, were that it was not necessary for DOE to develop a test procedure that is different from the test procedure specified in the ASHRAE 90.1 referenced test standards at the present time. NIST disagrees with the comments from the workshop attendees on this issue. Since a condensing boiler will provide a significantly higher efficiency, NIST believes that even if there is no commercial condensing boiler on the market at the present time, a test procedure should be provided for any future manufacturers of condensing boilers in order to give credit for their effort in providing users a product with a higher efficiency. In addition, a test procedure is needed for the future design option evaluation for the minimum efficiency standard. It is noted that even though the ASHRAE 90.1 referenced test standards do not specify a test procedure, there is an industry test procedure, the ASHRAE standard 103-1993, for measuring the increased energy efficiency of a residential condensing boiler under steady state test condition. The test procedure has been in practice over the last decade. Therefore, NIST recommends adopting the test procedure as specified in section 9.2 and 11.3.7 of ASHRAE Standard 103-1993 as an optional test procedure for the determination of the increment in energy efficiency due to the condensing feature of a condensing boiler.

Modular Boilers and Multiple Boilers

The issue of how to test a modular boiler assembly (consisting of a group of individual smaller boilers or modules installed as a unit with no intervening stop valves) or a multiple boiler assembly (consisting of a group of individual boilers installed as a unit with intervening stop valves between the individual boilers) was raised during the DOE April 1998 workshop. Since a modular boiler assembly or a multiple boiler assembly usually consisted of individual boilers or modules of similar design and construction, NIST recommends that for those type of commercial packaged boilers, a single boiler from the assembly be tested and its efficiency be applied as the efficiency rating of the boiler assembly.

<u>Testing a Steam and Hot Water Boiler as a Steam Boiler</u>

The current industry practice of testing a steam and hot water boiler as a steam boiler and reporting the efficiency rating as applicable to the boiler sold as a hot water boiler was discussed during the DOE April 1998 workshop. Since the steam test will generally provide an efficiency rating lower than the rating obtained by a hot water test, the comments suggested that this practice should be allowed in a DOE test procedure. NIST agrees with this and is proposing today that manufacturers be allowed the option of reporting the efficiency rating of a steam and hot water boiler from the test result obtained by testing the boiler as a steam boiler. Additionally, at the option of the manufacturers, the water version of a steam and water boiler may be tested as a water boiler.

4.3.3 Packaged Boiler Used As Hot Water Supply Boiler

Hot water supply boilers are designed and marketed to provide service water heating. Addendum n to ASHRAE Standard 90.1-1989 requires hot water supply boilers to meet the same energy efficiency requirements as water heaters. NIST recommends that the Department consider adoption of the ASHRAE approach related to commercial hot water supply boilers, requiring hot water supply boilers to meet the energy efficiency standards for commercial water heaters.

During the April 1998 workshop, the testing of a boiler that is used as a hot water supply boiler was discussed. The statute does not specifically list the term "hot water supply boiler" in the EPAct definitions for water heaters. EPAct, Sec.122(a)(1)(B)(F). However, the definition for an "unfired hot water storage tank" was included. Sec.122(a)(1)(B)(F), In certain installations, the hot water in an unfired hot water storage tank is supplied by a hot water supply boiler. As discussed in 4.2.2, the addendum n to ASHRAE Standard 90.1-1989 requires hot water supply boilers to meet the same energy efficiency requirements as instantaneous water heaters. Available evidence appears to indicate that this equipment meets the statutory definition of water heaters EPCA §340(12)(A). Therefore, NIST recommends that the Department consider adoption of the ASHRAE approach related to commercial hot water supply boilers.

4.3.4 Proposed Test Procedures for Commercial “Packaged” Boilers

NIST recommends a test procedure for measurement of the energy consumption and energy efficiency of Commercial “Packaged” Boilers, as outlined in Appendix E.

4.4 Test Protocols for Commercial Furnaces

4.4.1 General Discussions

This subsection discusses the main issues identified for the commercial furnaces. The issues are categorized under ASHRAE 90.1 referenced test standards, the definition of thermal efficiency, and the test procedures for the measurement of energy efficiency.

4.4.2 ASHRAE 90.1 Referenced Test Standards

EPCA requires that the testing procedures for measuring the efficiency of commercial warm air furnaces shall be those generally accepted industry testing procedures or rating procedures developed or recognized by the American Society of Heating, Refrigerating and Air Conditioning Engineers, as referenced in ASHRAE/IES Standard 90.1 and in effect on June 30, 1992. And if such an industry test procedure or rating procedure for warm air furnaces is amended, the Secretary of Energy is required to adopt such revisions unless the Secretary determines that to do so would not produce test results which reflect energy efficiency, energy use, and estimated operating costs, and would be burdensome to conduct.

As referenced in ASHRAE 90.1 and in effect on June 30, 1992, there is one industry test standard for gas fired furnaces and one for oil fired furnaces. These include the American National Standard Institute ANSI Z21.47-1987 for gas-fired central furnaces (ANSI Z21.47) and the Underwriters Laboratory Standard 727-1986 for oil-fired central furnaces (UL 727). Since the year 1989, both industry test standards have gone through multiple revisions. ANSI Z21.47-1987 was revised to ANSI Z21.47-1993, and UL 727-1986 was revised to UL 727-1994. Also, ASHRAE 90.1-1989 itself was revised via Addenda 90.1b, 90.1d, and 90.1e in 1992, 90.1c, 90.1g, and 90.1i in 1993, and 90.1m-1995 and 90.1n-1997. Currently, a revision to ASHRAE 90.1-1989, named ASHRAE 90.1-1989R, is going through the ASHRAE public review process.

Of the two industry test standards revised after June 30, 1992, there is no change in the energy performance test sections of either test standards from their prior versions. Therefore, NIST recommends that DOE incorporate by reference the latest versions of the two referenced test procedures. These test standards are ANSI Z21.47-1993 for gas-fired central furnaces and UL 727-1994 for oil-fired central furnaces.

4.4.3 Definition of Thermal Efficiency

EPCA specifies the term thermal efficiency for warm air furnaces. The referenced test standards explicitly (ANSI Z21.47) or implicitly (UL 727) specified the calculation of the thermal efficiency (Z21.47) or efficiency (UL 727) as equal to (100 - percent flue loss), which is the customary definition of combustion efficiency for fossil-fueled equipment. During the April 1998 workshop, the issue was raised as to whether the energy descriptor as defined in the statute should be renamed from thermal efficiency to combustion efficiency. The consensus of the attendees to the workshop were that in a DOE test procedure, the term thermal efficiency should remain as specified in the statute. Therefore, NIST recommends that DOE use the thermal efficiency as the energy descriptor for commercial warm air furnaces and define it as equal to 100 minus the percent flue loss, consistent with industry practice.

4.4.4 Test Procedures for the Measurement of Energy Efficiency

Flue Loss Calculation for Oil Fired Furnaces

As stated above, the referenced test standard for oil fired furnaces, UL 727, does not provide a calculation procedure for the determination of flue loss. However, the value for the percent loss is needed for determining the efficiency. To obtain a value for the flue loss, the flue loss calculation as specified in the ASHRAE 90.1 referenced test standard for oil fired boilers - the 1989 edition of the Hydronics Institute Testing and Rating Standard for Heating Boilers, was suggested as the procedure for calculating the flue loss of an oil fired furnace. There was no comment opposing that suggestion during the DOE April 1998 workshop. NIST is therefore proposing that the calculation procedure for flue loss as specified in the 1989 Hydronics Institute testing and rating standard for oil-fired boilers be adopted as the calculation procedure for flue loss for oil-fired furnaces.

Condensing Furnaces

The issue of testing a condensing furnace (a warm air furnace designed to condense part of the water vapor in the flue gases and is equipped with a means of collecting and draining this condensate) was raised and discussed during the DOE April 1998 workshop. ASHRAE 90.1 and the two test standards referenced by ASHRAE 90.1 do not specifically provide test conditions for testing a condensing furnace. Attendees at the April 1998 workshop from the furnace industry (GAMA, York International, and Lennox) stated that there are very few, if any, commercial (unitary equipment or rooftop) condensing furnaces on the market, and it is difficult to include the provision required of a condensing furnace in a roof-top installation. Therefore, it is not necessary to have a provision in a DOE test procedure for testing the condensing feature of a commercial furnace at the present time.

The Department of Energy disagrees with the comments from the workshop attendees on this issue. Since a condensing furnace will provide a significantly higher efficiency, DOE believes that, even if there is no commercial condensing furnace on the market at the present time, a test procedure should be provided for any future manufacturers of condensing furnaces in order to give credit for their effort in providing users a product with a higher efficiency. In addition, a test procedure is needed for the future design option evaluation for the minimum efficiency standard. It is noted that even though the ASHRAE 90.1 referenced test standards do not specify a test procedure, there is an industry test procedure, the ASHRAE standard 103-1993, for measuring the increased energy efficiency of a residential condensing furnaces under steady state test condition. That test procedure has been in use for the evaluation of the energy efficiency of residential central furnace over the last decade. Therefore, NIST recommends adopting the test procedure as specified in section 9.2 and 11.3.7 of ASHRAE Standard 103-1993 as an optional test procedure for the determination of the increment in energy efficiency due to the condensing feature of a condensing furnace.

4.4.5 Proposed Test Procedures for Commercial Furnaces

NIST recommends a test procedure for measurement of the energy consumption and energy efficiency of commercial furnaces, as outlined in Appendix F.

4.5 Test Protocols for Commercial Air Conditioners and Heat Pumps

During the April 1998 public workshop, discussions were held with representatives from the ARI, its manufacturer members, and Federal and state agencies on issues related to the test protocols for commercial air conditioners and heat pumps. Also, letters were subsequently received from Mr. William Keese, California Energy Commission, (dated May 28, 1998) and Mr. Lawrence R. Wethje, Air-Conditioning and Refrigeration Institute, (dated May 4, 1998.)

4.5.1 General Discussions

This subsection discusses the main issues identified for the commercial air conditioners and heat pumps. The issues are categorized under heat pumps with heating-only function and computer room air conditioners.

4.5.2 Heat Pumps with Heating-only Function

The heat pumps with heating-only functions do not appear to fall within the statutory definition for covered equipment (Title 42, Chapter 77, sec. 6311 (8), (9), (10)). This observation is of little practical consequence because, based on the information obtained from five major HVAC manufacturers and ARI, heating-only heat pumps are neither available on the U.S. market at this time nor are expected any time soon.

4.5.3 Computer Room Air Conditioners

A short data collection effort was conducted to obtain information about the computer room air conditioners. The HVAC/R Directory Source Guide published by the Air Conditioning, Heating & Refrigeration News (January 12, 1998) lists about thirty suppliers of air conditioners for data processing rooms. Over one half of the listed manufacturers supply spot coolers or "portable" cooling systems, which are used for backup cooling if the main cooling system either fails or falls short. Among the manufacturers/suppliers of primary cooling systems for computer rooms, there appear to be five or six key players including Liebert, Data Aire, Stulz, Air-Flow, and Compu-Aire.

Design Differences

While the basic design concept and vital components of computer room air conditioners are the same as those of human comfort air conditioners, certain design features are indeed different. These machines are typically designed to operate over a significantly smaller deadband around the set points, both for the temperature as well as for the humidity ratio. Accordingly, in addition to producing the desired cooling effect, these machines must also have the ability to humidify/dehumidify and reheat the air. The design latent capacity typically represents 15% of the total load, which is below that for comfort air conditioning. The most common settings for computer room air conditioner is a temperature of 72 °F and a relative humidity of 50%. In order to maintain a tighter control over the humidity ratio, frequent dehumidification is required. This dehumidification may have to be achieved by activating the unit to cool the air even under conditions when the temperature alone does not warrant it. This would push the temperature below the set point, which is then corrected by reheating the air. In order to accomplish all this, most computer room air conditioners incorporate sophisticated control systems, which add to the cost.

The ability of the units to maintain sufficient cooling effect under extreme conditions (over a typical range of 0 °F to 105 °F) is critical. The coils are usually larger and so is the air flow rate (typically 425-500 cfm/ton as compared to 400 cfm/ton for comfort air conditioners). Another difference in design concerns serviceability- the units have to be designed so that they can be serviced under any weather conditions. Unlike a typical comfort air conditioner, most of the controls and service-requiring components are located inside the building.

The reheat system may also be of a special design (low watt, finned tubular design) which would not get red hot (in order to avoid the triggering of smoke detectors through the burning of dust particles).

The manufacturing quality of the computer room air conditioner components also needs to be superior to that of comfort air conditioner components, because the equipment needs to operate for longer hours each day, requiring a longer run life.

<u>Efficiency of Computer Room Air Conditioners</u>

Representatives of computer room air conditioner manufacturers/suppliers contended that, to their customers, the ability of the units to operate under severe conditions and to remain within the narrow tolerance limits is crucial, and the cost of consumed energy is not a major consideration. Accordingly, high energy efficiency may not always be their primary concern. Most of them have heard about the energy efficiency regulations, but tend to relate these regulations to residential appliances. Very few appeared to be aware of the possibility that EPAct provisions, now already in effect, could apply to their equipment. At least one manufacturer is under the impression that their systems are exempt from regulations because they are designed for "process cooling environment" and not for "comfort cooling.”

When asked, most manufacturers/suppliers also did not appear to be intimidated by the EPAct efficiency levels (8.9 EER for small air-cooled commercial air conditioners and 8.5 EER for large air-cooled commercial air conditioners). With one exception, all representatives indicated that their units were already designed to operate close to the EPAct levels. This representative indicated an EER of 8.7 for most of their units. Based on conversations, it also appeared that while an EER of 9.0 is close to what is already available in the market, and is not considered a problem to meet, pushing the efficiency level up by one more point (i.e., an EER of 10.0) would definitely require significant changes in design and push up the equipment costs.

California Energy Commission (CEC) established a certification program for computer room air conditioners. Under this program, manufacturers certify to CEC their equipment using ANSI/ASHRAE Standard 127, “Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners”, rather than ARI Standard 210/240, which is stipulated by EPAct (via ASHRAE Standard 90.1). At the outset of the certification program, CEC tested a few computer room air conditioners according to both standards, determined equivalent levels of EER, and adopted EER levels for computer room air conditioners based on ASHRAE Standard 127 that were equivalent to those obtained based on ARI Standard 210/240. In April 1998, 637 certified computer room air conditioners were on CEC books.

While specific features of computer room air conditioners do not preclude them from achieving efficiency levels similar to those of the majority of the air conditioners offered on the market for different commercial applications, an opposing consideration comes from the fact that the currently used procedure for testing these systems, ASHRAE Standard 127, is not stipulated by ASHRAE Standard 90.1. During September 1998 ASHRAE 90.1 committee interim meeting held in Chicago, it was proposed that if computer room air conditioners are used primarily for cooling computers, they should be outside the scope of the Standard, whereas if they are used primarily for comfort cooling, they must be tested using the ARI standards cited in the standard.

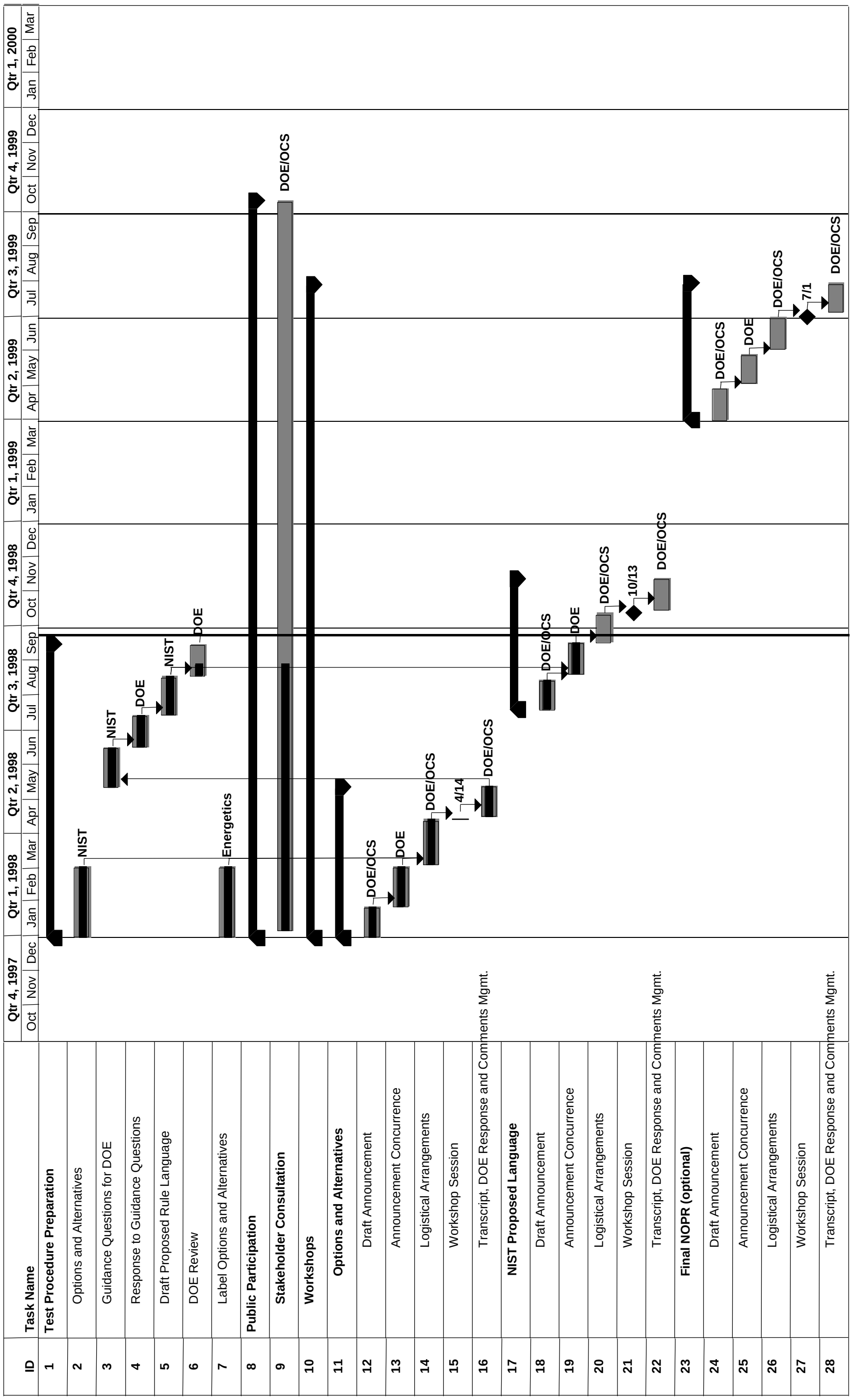
Based on the above discussions, the NIST recommendation is not to include computer room air conditioners as covered equipment when used primarily for cooling computers.

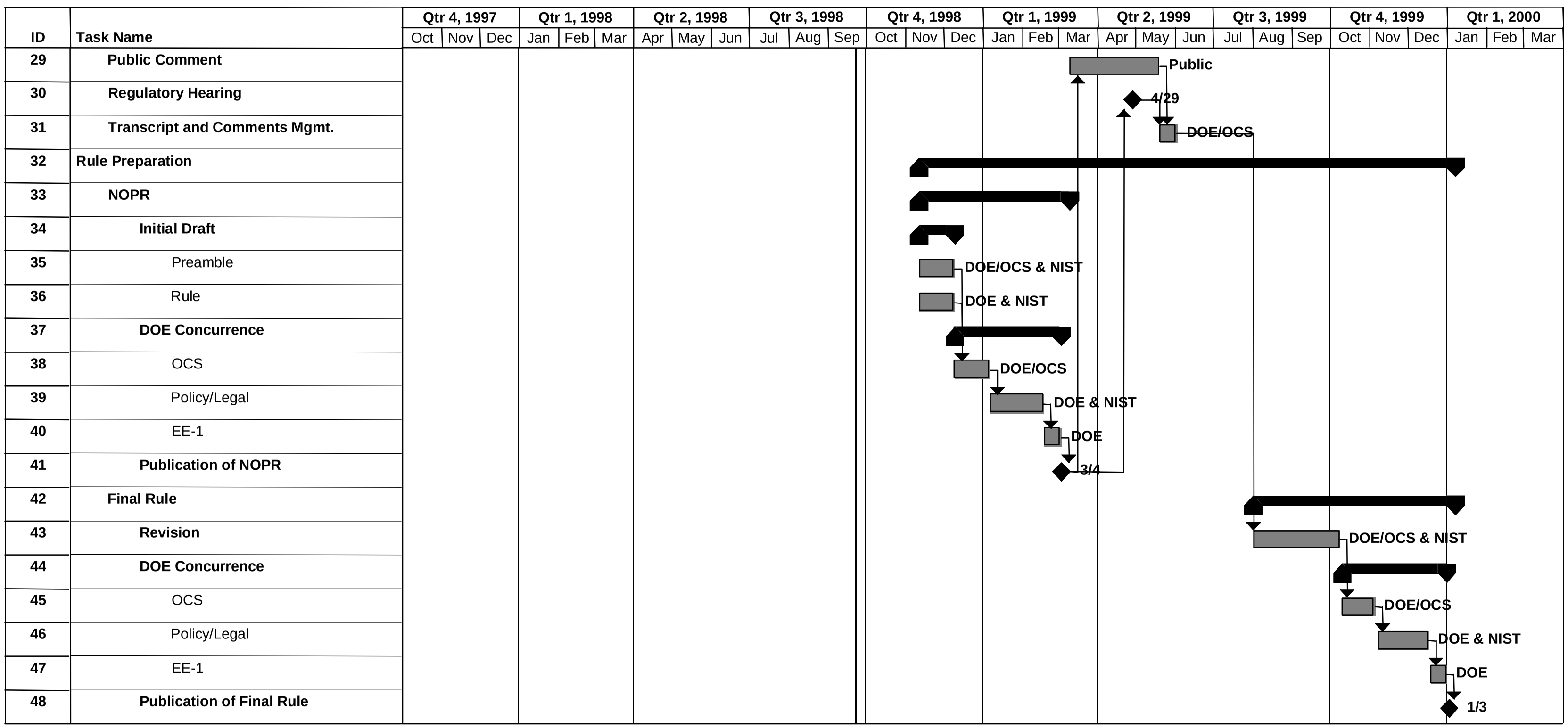
4.5.4 Proposed Test Procedures for Commercial Air Conditioners and Heat Pumps

NIST recommends a test procedure for measurement of the energy consumption and energy efficiency of commercial Air Conditioners and Heat Pumps, as outlined in Appendix G.

5.0 Milestone Chart

The following is DOE's milestone chart of follow-on activities for the commercial HVAC and water heating equipment rulemaking.





FILE Q:\data\ee-40\ee-43\43common\nasseri\nistrep\nistrept.wpd
October 2, 1998 (9:35AM)

APPENDIX A

COMPLIANCE CERTIFICATION AND ENFORCEMENT SAMPLING PROCEDURES

§431.24 Units to be tested.

For each basic model of a commercial air conditioner, heat pump, water heater, boiler and furnace, any representation of energy efficiency shall be determined based on testing results such that:

If the basic model is included in a DOE-approved voluntary independent certification program (as described in paragraph (g) of §431.62), the representation is the mean energy efficiency of the basic model population, as determined using valid statistical procedures, or;

If the basic model is not included in a DOE-approved voluntary independent certification program (as described in paragraph (g) of §431.62), a sample of sufficient size shall be tested to insure that-

(i) any represented value of energy efficiency shall be no greater than the lower of (A) the mean of the sample, or (B) the lower 95 percent confidence limit of the true mean divided by 0.95, or,

(ii) any represented value of energy usage shall be no less than the greater of (A) the mean of the sample, or (B) the upper 95 percent confidence limit of the true mean divided by 1.05.

§431.62 Submission of data.

(a) Compliance certification. (1) Each manufacturer or private labeler, before distributing in commerce any basic model of a covered equipment subject to the applicable energy conservation standard set forth in Subpart C of this part, shall certify to DOE (or to a DOE-approved voluntary independent certification program, as described in paragraph (g) of this section), by means of a compliance statement and a certification report, that each basic model meets the requirements of that standard on or before the effective date of the applicable energy conservation standard as prescribed in section 342 of the Act. Any documentation sent to DOE by a manufacturer or private labeler (or his representative, such as a trade association), shall be sent by certified mail to: Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC 20585-0121.

(2) The compliance statement, which shall be sent to DOE using the format set forth in this appendix, shall certify that:

(i) The basic model complies with the applicable energy conservation standards;

(ii) All required testing, on which certification reports (which can be sent either directly to DOE or to a DOE-approved voluntary independent certification program) are based, is conducted in conformance with the applicable test requirements prescribed in 10 CFR Part 431 Subpart B, and all test data are reported in accordance with this subpart;

(iii) All information reported in certification reports is true, accurate, and complete; and

(iv) The manufacturer or private labeler is aware of the penalties associated with violations of the Act and the regulations thereunder, and 18 U.S.C. 1001 which prohibits knowingly making false statements to the Federal Government.

(3) For each basic model of a covered equipment, the certification report, one possible format for which is set forth in this appendix, shall be submitted to a DOE-approved voluntary independent certification program, as described in paragraph (g) of this section, or to DOE. The certification report shall include the equipment type, equipment class (as denoted in §431.32), manufacturer's name, private labeler name(s), if applicable, the manufacturer's model number(s), and for:

(i) air-cooled three-phase electric central air conditioners and central air conditioning heat pumps less than 65,000 Btu per hour (cooling capacity), split systems or single package, the seasonal energy efficiency ratio and the heating seasonal performance factor.

(ii) air-cooled central air conditioners and central air conditioning heat pumps at or above 65,000 Btu per hour (cooling capacity) and less than 135,000 Btu per hour (cooling capacity), the energy efficiency ratio (at a temperature rating of 95 °F db) and the coefficient of performance in the heating mode (at a high temperature rating of 47 °F db).

(iii) water-cooled, evaporatively-cooled and water-source central air conditioners and central air conditioning heat pumps of less than 135,000 Btu per hour (cooling capacity), the energy efficiency ratio (at a standard rating of 95 °F db, for evaporatively cooled equipment, and 85 °F entering water temperature, for water-source and water-cooled equipment).

(iv) water-source heat pumps less than 135,000 Btu per hour (cooling capacity), the coefficient of performance in the heating mode (at a standard rating of 70 °F entering water temperature).

(v) air-cooled central air conditioners and central air conditioning heat pumps at or above 135,000 Btu per hour (cooling capacity) and less than 240,000 Btu per hour (cooling capacity), the energy efficiency ratio (at a standard rating of 95 °F db) and the coefficient of performance in the heating mode (at a high temperature rating of 47 °F db).

(vi) water- and evaporatively-cooled central air conditioners and central air conditioning heat pumps at or above 135,000 Btu per hour (cooling capacity) and less than 240,000 Btu per hour (cooling capacity), the energy efficiency ratio (according to ARI Standard 360-86).

(vii) packaged terminal air conditioners, the energy efficiency ratio (EER) in the cooling mode (at a temperature rating of 95 °F db).

(viii) packaged terminal heat pumps, the energy efficiency ratio (EER) in the cooling mode (at a temperature rating of 95 °F db), and the coefficient of performance (COP) in the heating mode (at a standard rating of 47 °F db).

(ix) gas- and oil-fired warm air furnaces (with a capacity of 225,000 Btu per hour or more), the minimum thermal efficiency at the maximum rated capacity.

(x) gas- and oil-fired commercial packaged boilers (with a capacity of 300,000 Btu per hour or more), the minimum combustion efficiency at the maximum rated capacity.

(xi) electric storage water heaters (except those having more than 140 gallon storage capacity and tank area thermally insulated to R-12.5), the maximum standby loss, in percent per hour.

(xii) gas- and oil-fired storage water heaters (except those having more than 140 gallon storage capacity, not including a standing pilot light, and tank area thermally insulated to R-12.5), the maximum standby loss, in percent per hour.

(xiii) instantaneous water heaters with a storage volume of less than 10 gallons, the minimum thermal efficiency in percent.

(xiv) instantaneous water heaters with a storage volume of 10 gallons or more (except those having more than 140 gallon storage capacity , not including a standing pilot light, and having the tank area thermally insulated to R-12.5), the minimum thermal efficiency in percent, and the maximum standby loss, in percent per hour.

(xv) for unfired hot water storage tanks (except those having more than 140 gallon storage capacity, not including a standing pilot light, and having the tank area thermally insulated to R-12.5), the maximum heat loss (Btu per hour per square foot of tank surface area).

(b) New models. All information required by paragraph (a) of this section must be submitted for new models prior to or concurrent with any distribution of such models. Any change to a basic model which affects energy consumption may constitute the addition of a new basic model subject to the requirements of §431.61. If such change does not alter compliance with the applicable energy conservation standard for the basic model, the new model shall be considered certified and not warrant additional testing. However, all information required by paragraph (a) of this section for the new model must be submitted either to the authorized trade association or to DOE (except for the compliance statement, which shall be submitted to DOE). Information submitted to DOE shall be sent, by certified mail, to: Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC 20585-0121.

(c) Discontinued model. A basic model is discontinued when its production has ceased and is no longer being distributed. Such models shall be reported to DOE, and sent by certified mail, to: Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC 20585-0121. For each basic model, this report shall include: equipment type, equipment class, the manufacturer's name, the private labeler name(s), if applicable, and the manufacturer's model number.

(d) Maintenance of records. The manufacturer or private labeler of any covered equipment subject to any of the energy performance standards, or procedures prescribed in this part shall establish, maintain, and retain the records of the underlying test data for all certification testing. Such records shall be organized and indexed in a fashion which makes them readily accessible for review by DOE upon request. The records shall include the supporting test data associated with tests performed on any test units to satisfy the requirements of this subpart. The records shall be retained by the manufacturer or private labeler for a period of two years from the date that production of the applicable model has ceased.

(e) Third party representation. A manufacturer or private labeler may elect to use a third party to submit the certification report to DOE (for example a trade association or other authorized representative). Such certification reports shall include all the information specified in paragraph (a)(3) of this section. The certification report must be submitted with a compliance statement as specified in paragraph (a)(2) of this section. A third party representative may also submit discontinued model information on behalf of an authorizing manufacturer or private labeler.

(f) Amendment of information. If any compliance certification information on a statement or report previously submitted to DOE has changed, the manufacturer, private labeler or his representative must submit the revised information, by certified mail, either to the authorized trade association or to DOE at: Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC 20585-0121.

(g) Voluntary Independent certification Program. A DOE-approved program which meets the following criteria:

(1) Energy efficiency performance metrics must be based on measurements.

(2) Testing must be conducted at an independent laboratory, or under the supervision of independent personnel, in accordance with the prescribed DOE test procedures.

(3) Periodic verification testing must be conducted on listed equipment, such that the performance of each basic model is checked at least every five years.

(4) Equipment which fails verification testing must either be removed from production and sale, or be delisted.

(5) Units selected for verification testing must be selected randomly from manufacturer's stock.

(6) The procedures for the operation of the certification program must be published in written form.

Voluntary independent certification programs can seek DOE approval by submitting to DOE, in writing, information substantiating their conformance to the above criteria.

§431.70 Enforcement.

(a) Performance standard - (1) Test notice. Upon receiving information in writing concerning the energy performance of a particular covered equipment sold by a particular manufacturer or private labeler which indicates that the covered equipment may not be in compliance with the applicable energy performance standard, according to §431.62, the Secretary may conduct testing of that covered equipment under this subpart by means of a test notice addressed to the manufacturer or private labeler in accordance with the following requirements:

(2) Testing Laboratory. Whenever DOE conducts enforcement testing at a designated laboratory in accordance with a test notice under this section, the resulting test data shall constitute official test data for that basic model. Such test data will be used by DOE to make a determination of compliance or noncompliance if a sufficient number of tests have been conducted to satisfy the requirements of appendix B of this subpart.

(3) Sampling. The determination that a manufacturer's basic model complies with the applicable energy performance standard shall be based on the testing conducted in accordance with the statistical sampling procedures set forth in this appendix and the test procedures set forth in Subpart B of this part. In the case of a basic model that has less than four units available for testing, all of the available units shall be tested, and the compliance determination based on the results of those measurements in a manner otherwise in accordance with appendix B of this subpart. In the case of a basic model which is very large, the manufacturer can petition the Department for an exception to the number of units to be tested, which if given sufficient justification, the Department can allow the testing of a single unit for enforcement.

(4) Test unit selection. A DOE inspector shall select a batch, a batch sample, and test units from the batch sample in accordance with the provisions of this paragraph and the conditions specified in the test notice.

(i) The batch may be subdivided by DOE utilizing criteria specified in the test notice, e.g., date of manufacture, component-supplier, location of manufacturing facility, or other criteria which may differentiate one unit from another within a basic model.

(ii) A batch sample of up to 20 units will then be randomly selected from one or more subdivided groups within the batch. The manufacturer shall keep on hand all units in the batch sample until such time as the basic model is determined to be in compliance or noncompliance.

(iii) Individual test units comprising the test sample shall be randomly selected from the batch sample.

(iv) All random selection shall be achieved by sequentially numbering all of the units in a batch sample and then using a table of random numbers to select the units to be tested.

(5) Test unit preparation. (i) Prior to and during testing, a test unit selected in accordance with paragraph (a)(4) of this section shall not be prepared, modified, or adjusted in any manner unless such preparation, modification, or adjustment is allowed by the applicable DOE test procedure. One test shall be conducted for each test unit in accordance with the applicable test procedures prescribed in subpart B.

(ii) No quality control, testing or assembly procedures shall be performed on a test unit, or any parts and subassemblies thereof, that is not performed during the production and assembly of all other units included in the basic model.

(iii) A test unit shall be considered defective if such unit is inoperative or is found to be in noncompliance due to failure of the unit to operate according to the manufacturer's design and operating instructions. Defective units, including those damaged due to shipping or handling, shall be reported immediately to DOE. DOE shall authorize testing of an additional unit on a case-by-case basis.

(6) Testing at manufacturer's option. If a manufacturer's basic model is determined to be in noncompliance with the applicable energy performance standard at the conclusion of DOE testing in accordance with the double sampling plan specified in appendix B of this subpart, the manufacturer may request that DOE conduct additional testing of the model according to procedures set forth in appendix B of this subpart.

APPENDIX C TO SUBPART F OF PART 431--COMPLIANCE CERTIFICATION

Statement of Compliance With Energy Conservation Standards for Commercial Equipment

Equipment: ___________________________________

Manufacturer's Name and Address

____

____

____

This compliance statement and the attached certification report (or a certification report Reference No.__________________Dated____________, filed with the DOE-approved voluntary independent certification program entitled ___________________________________) are submitted pursuant to 10 CFR part 431 (Energy Conservation Program for Commercial Equipment) and Part C of the Energy Policy and Conservation Act (Pub. L. 94-163), and amendments thereto. It is signed by a responsible official of the above named company. The basic models listed in the attached certification report (or the certification report filed with a DOE-approved voluntary independent certification program and referenced above) comply with the applicable energy conservation standard. All testing on which the attached certification report (or the certification report filed with a DOE-approved voluntary independent certification program and referenced above) is based was conducted in conformance with applicable test requirements prescribed in subpart B of 10 CFR part 431. All information reported in the attached certification report (or the certification report filed with a DOE-approved voluntary independent certification program and referenced above) is true, accurate, and complete. The company is aware of the penalties associated with violations of the Act and the regulations thereunder, and is also aware of the provisions contained in 18 U.S.C. 1001, which prohibits knowingly making false statement to the Federal Government.

Signature of Company Official: ____

Name: ____

Title: ____

Firm or Organization: ____

Date: ____

Name of Person to Contact for Further Information:

Name: ____

Address: ____

Telephone Number: ____

Facsimile Number: ____

Third Party Representative:

If any part of this Compliance Certification, including the attached certification report, was prepared by a third party organization under the provisions of §431.62 of 10 CFR 430, provide the following information for the company official who authorized third party representations:

Name: ____

Title: ____

Address: ____

Telephone Number: ____

Facsimile Number: ____

The third party organization officially acting as representative:

Third Party Organization: ____

Name: ____

Address: ____

Telephone Number: ____

Facsimile Number: ____

Submit Compliance Certification in writing or on a computer diskette, by Certified Mail either to the authorized trade association, or DOE at to: Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards, Forrestal Building, 1000 Independence Avenue, SW, Washington, DC 20585-0121.

Certification Report for Basic Models

(Attachment to Statement of Compliance with Energy Conservation Standards for Commercial Equipment)

Date: ____

Signature of Company Official or Third Party Representative: ______________________

Equipment Type: ____

Equipment Class: ____

Manufacturer: ____

Private Labeler (if applicable): ____

For New or Amended Models[1]:

For Discontinued Models[2]:

[1] Provide specific equipment information including, for each basic model, the manufacturer's model numbers and the information required in §431.62.

[2] Provide manufacturer's model number.

APPENDIX B

SAMPLING PLAN FOR ENFORCEMENT TESTING

APPENDIX B TO SUBPART F OF PART 431--SAMPLING PLAN FOR ENFORCEMENT TESTING

Double Sampling

Step 1. The first sample size ($\mathbf{n_1}$) must be four or more units.

Step 2. Compute the mean ($\bar{\mathbf{x}}_1$) of the measured energy performance of the $\mathbf{n_1}$ units in the first sample as follows:

$$\bar{x}_1 = \frac{1}{n_1}\left(\sum_{i=1}^{n_1} x_i\right) \qquad (1)$$

where ($\mathbf{x_i}$) is the measured energy efficiency or energy consumption of unit I.

Step 3. Compute the standard deviation ($\mathbf{s_1}$) of the measured energy performance of the ($\mathbf{n_1}$) units in the first sample as follows:

$$s_1 = \sqrt{\frac{\sum_{i=1}^{n_1}(x_i - \bar{x}_1)^2}{n_1 - 1}} \qquad (2)$$

Step 4. Compute the standard error ($s_{\bar{x}_1}$) of the measured energy performance of the $\mathbf{n_1}$ units in the first sample as follows:

$$s_{\bar{x}_1} = \frac{s_1}{\sqrt{n_1}} \qquad (3)$$

Step 5. Compute the upper control limit (UCL_1) and lower control limit (LCL_1) for the mean of the first sample using the applicable DOE energy performance standard (EPS) as the desired mean and a probability level of 95 percent (two-tailed test) as follows:

$$\boldsymbol{LCL_1 = EPS - ts_{\bar{x}_1}} \qquad \textbf{(4)}$$

$$\boldsymbol{UCL_1 = EPS + ts_{\bar{x}_1}} \qquad \textbf{(5)}$$

where t is a statistic based on a 95 percent two-tailed probability level and a sample size of $\mathbf{n_1}$.

Step 6(a). For an Energy Efficiency Standard, compare the mean of the first sample ($\bar{\mathbf{x}}_1$) with the upper and lower control limits (UCL_1 and LCL_1) to determine one of the following:

(1) If the mean of the first sample is below the lower control limit, then the basic model is in noncompliance and testing is at an end. (Do not go on to any of the steps below.)

(2) If the mean of the first sample is equal to or greater than the upper control limit, then the basic model is in compliance and testing is at an end. (Do not go on to any of the steps below.)

(3) If the sample mean is equal to or greater than the lower control limit but less than the upper control limit, then no determination of compliance or noncompliance can be made and a second sample size is determined by Step 7(a).

Step 6(b). For an Energy Consumption Standard, compare the mean of the first sample ($\bar{\mathbf{x}}_1$) with the upper and lower control limits (UCL_1 and LCL_1) to determine one of the following:

(1) If the mean of the first sample is above the upper control limit, then the basic model is in noncompliance and testing is at an end. (Do not go on to any of the steps below.)

(2) If the mean of the first sample is equal to or less than the lower control limit, then the basic model is in compliance and testing is at an end. (Do not go on to any of the steps below.)

(3) If the sample mean is equal to or less than the upper control limit but greater than the lower control limit, then no determination of compliance or noncompliance can be made and a second sample size is determined by Step 7(b).

Step 7(a). For an Energy Efficiency Standard, determine the second sample size (**n_2**) as follows:

$$n_2 = \left(\frac{ts_1}{0.05\ EPS} \right)^2 - n_1 \qquad (6a)$$

where s_1 and t have the values used in Steps 4 and 5, respectively. The term "0.05 EPS" is the difference between the applicable energy efficiency standard and 95 percent of the standard, where 95 percent of the standard is taken as the lower control limit. This procedure yields a sufficient combined sample size (**n_1+n_2**) to give an estimated 97.5 percent probability of obtaining a determination of compliance when the true mean efficiency is equal to the applicable standard. Given the solution value of n_2, determine one of the following:

(1) If the value of n_2 is less than or equal to zero and if the mean energy efficiency of the first sample (**$\bar{x}_1$**) is either equal to or greater than the lower control limit (LCL_1) or equal to or greater than 95 percent of the applicable energy efficiency standard (EES), whichever is greater, i.e., if **$n_2 \leq 0$** and **$\bar{x}_1$** $\geq$ max (LCL_1, 0.95 EES), the basic model is in compliance and testing is at an end.

(2) If the value of n_2 is less than or equal to zero and the mean energy efficiency of the first sample (**$\bar{x}_1$**) is less than the lower control limit (LCL_1) or less than 95 percent of the applicable energy efficiency standard (EES), whichever is greater, i.e., if **$n_2 \leq 0$** and $\bar{x}_1$ < max (LCL_1, 0.95 EES), the basic model is in noncompliance and testing is at an end.

(3) If the value of n_2 is greater than zero, then value of the second sample size is determined to be the smallest integer equal to or greater than the solution value of **n_2** for equation (6a). If the value of **n_2** so calculated is greater than **$20-n_1$**, set n_2 equal to **$20-n_1$**.

Step 7(b). For an Energy Consumption Standard, determine the second sample size (n_2) as follows:

$$n_2 = \left(\frac{ts_1}{0.05\ EPS} \right)^2 - n_1 \qquad (6b)$$

where s_1 and t have the values used in Steps 4 and 5, respectively. The term "0.05 EPS" is the difference between the applicable energy consumption standard and 105 percent of the standard, where 105 percent of the standard is taken as the upper control limit. This procedure yields a sufficient combined sample size (**n_1 + n_2**) to give an estimated 97.5 percent probability of obtaining a determination of compliance when the true mean consumption is equal to the applicable standard. Given the solution value of **n_2**, determine one of the following:

(1) If the value of n_2 is less than or equal to zero and if the mean energy consumption of the first sample (**$\bar{x}_1$**) is either equal to or less than the upper control limit (UCL_1) or equal to or less than 105 percent of the applicable energy performance standard (EPS), whichever is less, i.e., if **n_2** ≤ 0 and $\bar{x}_1 \leq$ min (UCL_1, 1.05 EPS), the basic model is in compliance and testing is at an end.

(2) If the value of n_2 is less than or equal to zero and the mean energy consumption of the first sample ($\bar{x}_1$) is greater than the upper control limit (UCL_1) or more than 105 percent of the applicable energy performance standard (EPS), whichever is less, i.e., if **$n_2 \leq 0$** and **$\bar{x}_1$** > min (LCL_1, 1.05 EPS), the basic model is in noncompliance and testing is at an end.

(3) If the value of **n_2** is greater than zero, then the value of the second sample size is determined to be the smallest integer equal to or greater than the solution value of n_2 for equation (6b). If the value of n_2 so calculated is greater than **$20-n_1$**, set n_2 equal to **$20-n_1$.**

Step 8. Compute the combined mean (**$\bar{x}_2$**) of the measured energy performance of the **n_1** and **n_2** units of the combined first and second samples as follows:

$$\bar{x}_2 = \frac{1}{n_1+n_2} \left(\sum_{i=1}^{n_1+n_2} x_i \right) \qquad (7)$$

Step 9. Compute the standard error ($s_{\bar{x}_2}$) of the measured energy performance of the **n_1** and **n_2** units in the combined first and second samples as follows:

$$s_{\bar{x}_2} = \frac{s_1}{\sqrt{n_1 + n_2}} \qquad (8)$$

Note: $\mathbf{s_1}$ is the value obtained in Step 3.

Step 10(a). For an Energy Efficiency Standard, compute the lower control limit (LCL_2) for the mean of the combined first and second samples using the DOE energy efficiency standard (EES) as the desired mean and a one-tailed probability level of 97.5 percent (equivalent to the two-tailed probability level of 95 percent used in Step 5) as follows:

$$LCL_2 = EES - ts_{\bar{x}_2} \qquad (9a)$$

where the t-statistic has the value obtained in Step 5.

Step 10(b). For an Energy Consumption Standard, compute the upper control limit (UCL_2) for the mean of the combined first and second samples using the DOE energy performance standard (EPS) as the desired mean and a one-tailed probability level of 102.5 percent (equivalent to the two-tailed probability level of 95 percent used in Step 5) as follows:

$$UCL_2 = EPS + ts_{\bar{x}_2} \qquad (9b)$$

where the t-statistic has the value obtained in Step 5.

Step 11(a). For an Energy Efficiency Standard, compare the combined sample mean ($\bar{\mathbf{x}}_2$) to the lower control limit (LCL_2) to find one of the following:

(1) If the mean of the combined sample ($\bar{\mathbf{x}}_2$) is less than the lower control limit (LCL_2) or 95 percent of the applicable energy efficiency standard (EES), whichever is greater, i.e., if $\bar{\mathbf{x}}_2 < \max(LCL_2, 0.95\ EES)$, the basic model is in noncompliance and testing is at an end.

(2) If the mean of the combined sample ($\bar{\mathbf{x}}_2$) is equal to or greater than the lower control limit

(LCL_2) or 95 percent of the applicable energy efficiency standard (EES), whichever is greater, i.e., if $\bar{\mathbf{x}}_2 \geq$ max (LCL_2, 0.95 EES), the basic model is in compliance and testing is at an end.

Step 11(b). For an Energy Consumption Standard, compare the combined sample mean ($\bar{\mathbf{x}}_2$) to the upper control limit (UCL_2) to find one of the following:

(1) If the mean of the combined sample ($\bar{\mathbf{x}}_2$) is greater than the upper control limit (UCL_2) or 105 percent of the applicable energy performance standard (EPS), whichever is less, i.e., if $\bar{\mathbf{x}}_2 >$ min (UCL_2, 1.05 EPS), the basic model is in noncompliance and testing is at an end.

(2) If the mean of the combined sample ($\bar{\mathbf{x}}_2$) is equal to or less than the upper control limit (UCL_2) or 105 percent of the applicable energy performance standard (EPS), whichever is less, i.e., if $\bar{\mathbf{x}}_2 \leq$ min (UCL_2, 1.05 EPS), the basic model is in compliance and testing is at an end.

Manufacturer-Option Testing

If a determination of non-compliance is made in Steps 6, 7 or 11, the manufacturer may request that additional testing be conducted, in accordance with the following procedures.

Step A. The manufacturer requests that an additional number, $\mathbf{n_3}$, of units be tested, with $\mathbf{n_3}$ chosen such that $\mathbf{n_1+n_2+n_3}$ does not exceed 20.

Step B. Compute the mean energy performance, standard error, and lower or upper control limit of the new combined sample in accordance with the procedures prescribed in Steps 8, 9, and 10, above.

Step C. Compare the mean performance of the new combined sample to the revised lower or upper control limit to determine one of the following:

a.1. For an Energy Efficiency Standard, if the new combined sample mean is equal to or greater than the lower control limit or 95 percent of the applicable energy efficiency standard, whichever is greater, the basic model is in compliance and testing is at an end.

a.2. For an Energy Consumption Standard, if the new combined sample mean is equal to or less than the upper control limit or 105 percent of the applicable energy consumption standard, whichever is less, the basic model is in compliance and testing is at an end.

b.1. For an Energy Efficiency Standard, if the new combined sample mean is less than the lower control limit or 95 percent of the applicable energy efficiency standard, whichever, is greater, and the value of $\mathbf{n_1+n_2+n_3}$ is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated.

b.2. For an Energy Consumption Standard, if the new combined sample mean is greater than the upper control limit or 105 percent of the applicable energy consumption standard, whichever is less, and the value of $\mathbf{n_1+n_2+n_3}$ is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated.

c. Otherwise, the basic model is determined to be in noncompliance.

Appendix C

Commercial Water Heater Test Procedures

APPENDIX F TO SUBPART B OF PART 431 - UNIFORM TEST METHOD FOR MEASURING THE THERMAL EFFICIENCY AND STANDBY LOSS OF COMMERCIAL WATER HEATERS AND HOT WATER SUPPLY BOILERS

1. Scope: This appendix applies to the determination of thermal efficiency and standby loss of storage water heaters, instantaneous water heaters and hot water supply boilers as defined in this appendix.

2. Definitions

2.1 *Hot water supply boiler* means a boiler used to heat water for purposes other than space heating with an input rating of at least 300,000 Btu/h.

2.2 *Instantaneous water heater* means a water heater that has an input rating of at least 4000 Btu per hour per gallon of stored water. Such term does not include gas instantaneous water heaters used to heat potable water with an input of 200,000 Btu per hour or less, oil instantaneous water heaters used to heat potable water with an input of 210,000 Btu per hour or less, and electric instantaneous water heaters used to heat potable water with an input of 12 kilowatts or less unless such unit is designed to heat water to temperatures of 180°F or higher.

2.3 *R-value* means the thermal resistance of insulating material as determined based on ASTM Standard Test Method C177-85 or C518-91.

2.4 *Standby loss* means the ratio of the heat loss per hour to the heat content of the stored water above room temperature, in percent per hour as determined by the formula for S given in ANSI Z21.10.3-1993.

2.5 *Storage water* heater means a water heater that heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand. Such term does not include units with an input rating of 4000 Btu per hour or more per gallon of stored water. Such term also does not include gas storage water heaters used to heat potable water with an input of 75,000 Btu per hour or less, oil storage water heaters used to heat potable water with an input of 105,000 Btu per hour or less, and electric storage water heaters used to heat potable water with an input of 12 kilowatts or less.

2.6 *Tank surface area*, for the purpose of determining portions of a tank requiring insulation, tank surface area means those areas of a storage tank, including access panels and hatches, in its uninsulated or preinsulated state that do not have pipe penetrations or tank supports attached.

2.7 *Thermal efficiency* means the ratio of the heat transferred to the water flowing through the water heater to the amount of energy consumed by the water heater as measured during the thermal efficiency test procedure presented in this appendix.

3. Test Procedures

3.1 Thermal Efficiency

3.1.1 *Measurement Equipment*

Measurement equipment specifications shall be as provided in the Instrumentation subsection of Appendix E to Subpart B of 10 CFR Part 430.

3.1.2 *Test Setup*

3.1.2.1 *Gas-fueled water heaters*

Test setup and instrumentation shall conform to the subsection titled Method of Test of section 2.8 in ANSI Z21.10.3-1993. Hot water supply boilers shall be treated as instantaneous water heaters.

3.1.2.2 *Oil-fueled water heaters*

Test setup and instrumentation shall conform to the subsection titled Method of Test of Section 2.8 in ANSI Z21.10.3-1993, except as noted. Hot water supply boilers shall be treated as instantaneous water heaters. When testing an oil-fueled water heater, a vertical length of flue pipe shall be connected to the flue gas outlet of sufficient height to establish the minimum draft specified in the manufacturer's installation instructions. The burner rate shall be adjusted to achieve an hourly Btu input rate within +/- 2% of the manufacturer's specified input rate with the CO_2 reading as specified by the manufacturer with smoke no greater than 1 and fuel pump pressure within +/- 1% of the manufacturer's specifications.

3.1.2.3 *Electric water heaters*

The thermal efficiency of electric water heaters with immersed heating elements is assumed to be 98 percent.

3.1.3 *Test Method*

Method of test shall conform to the subsection titled Method of Test of Section 2.8 in ANSI Z21.10.3-1993.

3.2 Standby Loss

3.2.1 *Measurement Equipment*

Measurement equipment specifications shall be as provided in the Instrumentation subsection of Appendix E to Subpart B of 10 CFR Part 430.

3.2.2 *Test Setup*

3.2.2.1 *Gas-fueled water heaters*

Test setup and instrumentation shall conform to subsection titled Method of Test of Section 2.9 in ANSI Z21.10.3-1993.

3.2.2.2 *Oil-fueled water heaters*

Test setup and instrumentation shall conform to Section 3.1.2.2 of this appendix.

3.2.2.3 *Electric water heaters*

Test setup and instrumentation shall conform to the subsection titled Method of Test of Section 2.9 in ANSI Z21.10.3-1993, except as noted below. When testing an electric water heater for standby loss, the electrical supply voltage shall be maintained within +/- 1% of the center of the voltage range specified on the water heater nameplate.

3.2.3 *Test Method*

Method of testing shall conform to the subsection titled Method of Test of Section 2.9 in ANSI Z21.10.3-1993, except as noted. When testing electric water heaters, the value of E_t required for calculation of the standby loss (S) shall be 98 percent.

Appendix D

Unfired Hot Water Storage Tank Test Procedures

APPENDIX G TO SUBPART B OF PART 431 - UNIFORM TEST METHOD FOR DETERMINING THE MAXIMUM HEAT LOSS OF COMMERCIAL UNFIRED HOT WATER STORAGE TANKS

1. Scope: This appendix applies to the determination of the maximum heat loss of commercial unfired hot water storage tanks.

2. Definitions:

2.1 *Nominal tank surface area* means the area of the tank if it is uninsulated or the area of the jacket if it is a jacketed storage tank. This surface area will be determined by assuming that no holes or protrusions exist in or from the main body of the tank or jacket.

2.2 *R-value* means the thermal resistance of insulating material as determined based on ASTM Standard Test Method C177-85 or C518-91.

2.3 *Tank surface area*, for the purpose of determining portions of a tank requiring insulation, tank surface area means those areas of a storage tank, including access panels and hatches, in its uninsulated or preinsulated state that do not have pipe penetrations or tank supports attached during operation. For the purpose of calculating heat loss per square foot of tank surface area, the nominal tank surface area will be used.

2.4 *Unfired hot water storage tank* means a tank used to store water that is heated externally.

3. Test Procedures

3.1 *Equivalent Electric Storage Tank Method*

3.1.1 *Scope*

This method can be used to determine the heat loss per square foot of tank surface area for unfired hot water storage tanks by performing the standby loss test procedure on an electric storage water heater utilizing an identical tank with identical insulation and jacketing as that of the unfired storage tank model.

3.1.2 *Test Equipment*

3.1.3 *Test Method*

Perform the standby loss test procedure as provided in Appendix F to Subpart B of Part 431.

3.1.4 *Calculations*

Determine the difference in internal energy of the volume of water in the tank at the beginning and end of the test based on the mean tank temperature, Q_{diff}, in Btu as follows:

$$Q_{diff} = K \cdot V_a \cdot \Delta T_4$$

where the terms on the right-hand-side of the equation are the same as those presented in Section

2.9 of ANSI Z21.10.3-1993.

Determine the rate of heat loss per square foot of tank surface area, Q_{loss}, in Btu/h·ft^2 as follows:

$$Q_{loss} = \frac{E_c - \dfrac{Q_{diff}}{h_t / 100}}{A_s \cdot t}$$

where

- E_c = electrical energy consumption as presented in Section 2.9 of ANSI Z21.10.3-1993,
- A_s = nominal surface area of the tank, ft^2 (m^2),
- η_t = 98%, the assumed recovery efficiency for electric water heaters with immersed heating elements,
- t = duration of standby loss test as defined in Section 2.9 of ANSI Z21.10.3-1993.

3.2 *Externally Heated Water Method*

3.2.1 *Scope*

This method can be used to determine the heat loss per square foot of tank surface area. This is an alternate method to be used if the Equivalent Electric Storage Tank Method is not applicable.

3.2.2. *Measurement Equipment*

Measurement equipment specifications shall be as provided in the Instrumentation subsection of Appendix E to Subpart B of 10 CFR Part 430.

Measurement equipment shall be installed to measure electrical power and energy consumption, internal tank storage temperature, ambient temperature and storage volume of the unfired storage tank as indicated in Appendix E to Subpart B of 10 CFR Part 430.

3.2.3 *Test Setup*

Connect a water heater(s) of a type recommended by the storage tank manufacturer, with a known thermal efficiency rating and storage tank capacity as determined by Appendix F to Subpart B of CFR 431, to the storage tank according to the manufacturers instructions provide a recirculation loop between the water heater and storage tank and a pump to provide circulation. The circulation loop between the water heater and storage tank shall be of minimum length. Insulate all piping connected to the storage tank with a material having a thermal resistance (R-value) of not less than 4 °F·ft^2·hr/Btu (0.7 K·m^2/W).

Maintain ambient air temperature according to ANSI Z21.10.3-1993 Section 2.8.i.

3.2.4 *Test Method*

- Determine capacity of unfired storage tank according to Section 2.30 of ANSI Z21.10.3-1993.
- Establish a maximum mean unfired storage tank temperature of 160 ± 5°F.
- Record electric and fuel measurement instrument readings, tank temperatures and time.
- Do not add heat to the unfired storage tank for the next 48 hours.
- After the 48 hour standby period has elapsed:
  - Record the electric and fuel measurement readings
  - Record the tank temperatures and time
  - Activate the water heater
- Recovery - Establish a mean tank temperature of 160 ± 5°F while circulating water between the water heater and the unfired storage tank
  - Record the electric and fuel measurement readings
  - Record tank temperatures and time

3.2.5 *Calculations*

Data required:

- V_{R_fuel} Volume of fuel consumed during recovery period
- CF Correction factor for fuel
- H Heating value of fuel
- T_{S_mi} Mean tank temperature at beginning of the standby period
- T_{R_mf} Mean tank temperature at the end of the recovery period
- η_t Thermal efficiency of the hot water heater
- t_S Standby loss period in hours
- V_t Storage capacity of unfired storage tank
- Q_{pipe} Heat loss rate of water from recirculation loop

  (optional - calculated based on water temperature in pipe, pipe dimensions, and insulation)

Calculate the amount of energy required to heat the water during the recovery period, Q_R as follows:

For gas,

$$Q_R = V_{R\_fuel} \cdot CF \cdot H$$

Determine the difference in internal energy of the volume of water in the unfired storage tank at the beginning of the test standby loss period and at the end of the recovery period based on the mean tank temperature, Q_{diff}, in Btu as follows:

$$Q_{diff} = V_t \cdot K \cdot \left(T_{R\_mf} - T_{S\_mi}\right)$$

Calculate the rate of heat loss per square foot of tank surface area during the test standby loss period, q_{loss}, based on the amount of heat required to reheat the water during the recovery period.

$$q_{loss} = \frac{Q_R \cdot h_t - \frac{Q_{diff}}{h_t} - Q_{pipe}}{t_S \cdot A_t}$$

Appendix E

Commercial “Packaged” Boilers Test Procedures

APPENDIX E TO SUBPART B OF PART 431--UNIFORM TEST METHOD FOR MEASURING THE ENERGY EFFICIENCY OF PACKAGED COMMERCIAL HEATING BOILERS

1.0 Scope

1.1 This Appendix covers the test procedures used to measure the steady state combustion efficiency of gas-fired or oil-fired, packaged commercial heating boilers having a rated capacity of 300,000 Btu per hour or more.

1.2 Packaged boiler covered by this Appendix is defined as “a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections”.

1.2.1 Packaged low-pressure steam and hot water boilers shall conform to the requirements of the current edition of the ASME Boiler and Pressure Vessel Code, Section IV, Heating Boilers.

1.2.2 Packaged high-pressure steam and high temperature water boilers shall conform to the requirements of the ASME Boiler and Pressure Vessel Code, Section I, Power Boilers.

2.0 Definitions

2.1 Definitions include the definitions specified in section 3.0 of the Hydronics Institute Testing and Rating Standard for Heating Boilers, sixth edition, June 1989, and the following additional definitions for condensing boilers:

2.1.1 Condensing Boiler - a boiler which will, during the laboratory test, condense part of the water vapor in the flue gases and which is equipped with a means of collecting and draining this condensate.

2.1.2 Flue Condensate - liquid formed by the condensation of moisture in the flue gases.

3.0 Test Procedures

3.1 Test Procedure for Packaged Low-Pressure Steam and Hot Water Boilers.

3.1.1 Classifications: The classification of boilers shall be as specified in section 4.0 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers

3.1.2 Requirements: The requirements for the combustion efficiency test shall be conducted as specified in sections 5.1.2, 5.2, 5.4.1, 5.4.3, 5.4.4, 5.4.5, and 5.4.6 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers.

3.1.3 Instruments and Apparatus: The requirements for instruments and apparatus shall be as specified in sections 6 and 7 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers.

3.1.4 Test Conditions: The test conditions shall be as specified in section 8.0 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers with the exception of subsection 8.5.1 (of the HI standard) which is replaced with the following paragraph:

3.1.4.1 Water Temperatures - for water test, the boiler inlet temperature shall be at 80F ±10F and the boiler outlet temperature shall be at 180F±2F.

3.1.5 Test Procedure:

3.1.5.1 The test procedure for the combustion efficiency test shall be as specified in sections 9.2 and 10.2 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers.

3.1.5.2 Optional Procedure for the Measurement of Condensate for a Condensing Boiler. The test procedure for the measurement of the condensate from the flue gas under steady state operation shall be conducted as specified in section 9.2 of ASHRAE standard 103-1993 under the rated input conditions. This condensate measurement, if selected to be conducted, shall be for an additional 30 minutes of steady state operation after the completion of the steady state combustion efficiency test specified in sec. 2.6.1 of this appendix.

3.1.5.3 Steam and Water Boilers. A steam and water boiler shall be tested as steam boiler. Optionally, the water version of a steam and water boiler may be tested as a water boiler.

3.1.6 Calculation of Results:

3.1.6.1 Combustion Efficiency. The calculation procedure for the combustion efficiency test shall be as specified in section 11.2 of the 1989 Hydronics Institute Testing and Heating Standard for Heating Boilers.

3.1.6.2 Procedure for the Calculation of the Additional Heat Gain and Heat loss, and Adjustment to the Combustion Efficiency for a Condensing Boiler

3.1.6.2.1 If the optional procedure for the measurement of flue condensate of sec. 2.6.2 of this Appendix is selected, the calculation of the latent heat gain from the condensation of the water vapor in the flue gas and heat loss of due to the flue condensate down the drain shall be as specified in section 11.3.7.1 and 11.3.7.2 of ASHRAE Standard 103-1993.

3.1.6.2.2 Adjustment to the Combustion Efficiency for Condensing Boiler. The combustion efficiency as calculated in section 2.7.1 of this Appendix shall be adjusted by adding the latent gain from the condensation of the water vapor in the flue gas and subtracting the heat loss (due to the flue condensate down the drain) to obtain the combustion efficiency of a condensing boiler.

Appendix F

Commercial Furnace Test Procedures

APPENDIX D TO SUBPART B OF PART 431: UNIFORM TEST PROCEDURE FOR THE MEASUREMENT OF ENERGY EFFICIENCY OF COMMERCIAL WARM AIR FURNACES

1.0 Scope:

1.1 This appendix covers the test procedures used for the measuring of the steady state thermal efficiency of commercial warm air gas fired central furnaces and commercial warm air oil fired central furnaces with capacity of 225,000 Btu/h or more.

1.2 For purpose of this Appendix, the measured thermal efficiency is equal to (100 - percent flue loss).

2.0 Definitions

2.1 Gas Fired Central Furnaces. Definition terms for gas fired central furnaces shall be as specified in PART XI - DEFINITIONS, of the American National Standards Institute (ANSI) Standard ANSI Z21.47-1993.

2.2 Oil Fired Central Furnaces. Definition terms for oil fired central furnaces shall be as specified in section 3 - Glossary, of the Underwriters Laboratories, Inc. Standard for Oil-Fired Central Furnaces, UL 727-1994.

3.0 Test Procedures

3.1 Gas Fired Central Furnaces. The test setup, flue requirement, instrumentation, test condition, and measurement for measuring the thermal efficiency of gas fired central furnaces with rated input of 225,000 Btu/h or more, shall be as specified in sections 2.1 through 2.11, section 2.37 (Thermal Efficiency), and section 4.2 of the American National Standards Institute/National Standard of Canada (ANSI/CSC) Standard for Gas-Fired Central Furnaces, ANSI/CSC 21.47-1993.

3.2 Oil Fired Central Furnaces. The test setup, flue requirement, instrumentation, test condition, and measurement for measuring the thermal efficiency of oil fired central furnaces with rated input of 225,000 Btu/h or more, shall be as specified in sections 31 through 41, section 42 (Combustion Test - Burner and Furnace), and section 47 (Temperature Tests), of the Underwriters Laboratories Standard for Oil-Fired Central Furnaces, UL 727-1994.

3.2.1 Measurement of Flue CO_2 (Carbon Dioxide). In addition to the flue temperature measurement as specified in section 40.6.8 of UL 727, one or two sampling tubes shall be located within six inches downstream from the flue temperature probe (as indicated on Figure 40.3 of UL 727). If an open end tube is used, it shall project into the flue one-third of the chimney connector diameter. If other methods of sampling are used, the sampling tube shall be placed so as to obtain an average sample. There shall be no air leak between the temperature probe and the sampling tube location. The flue gas sample shall be collected at the same time the flue gas temperature is recorded. The CO_2 concentration of the flue gas shall be as specified by the manufacturer with a tolerance of ±0.1%. The flue CO_2 shall be determined with an instrument providing a reading with an error no greater than ±0.1%.

3.3 Optional Procedure for the Measurement of Condensate for a Gas-Fired Condensing Furnace. The test procedure for the measurement of the condensate from the flue gas under steady state operation shall be conducted as specified in section 9.2 of ASHRAE standard 103-1993 under the rated input conditions. This condensate measurement, if selected to be conducted, shall be for an additional 30 minutes of steady state operation after the completion of the steady state combustion efficiency test specified in sec. 2.1 of this appendix.

3.4 Calculation.

3.4.1 Gas Fired Central Furnaces. The calculation procedure shall be as specified in section 2.37, Thermal Efficiency, of ANSI Z21.47-1993.

3.4.2 Oil Fired Central Furnaces. The calculation procedure for the percent flue loss and the steady state efficiency shall follow the procedure specified in section 11.2 (Combustion Efficiency Test) of the 1989 Hydronics Institute (H.I) Testing and Heating Standard for Heating Boilers. The thermal efficiency shall be calculated as:

Thermal Efficiency = 100 percent - percent flue loss.

3.4.3 Procedure for the Calculation of the Additional Heat Gain and Heat loss, and Adjustment to the Combustion Efficiency for a Condensing Furnace.

3.4.3.1 If the optional procedure for the measurement of flue condensate of sec. 2.3 of this Appendix is selected, the calculation of the latent heat gain from the condensation of the water vapor in the flue gas and heat loss of due to the flue condensate down the drain shall be as specified in section 11.3.7.1 and 11.3.7.2 of ASHRAE Standard 103-1993.

3.4.3.2 Adjustment to the Combustion Efficiency for Condensing Furnace. The combustion efficiency as calculated in sec. 3.1 of this Appendix shall be adjusted by adding the latent gain from the condensation of the water vapor in the flue gas and subtracting the heat loss (due to the flue condensate down the drain) to obtain the combustion efficiency of a condensing furnace.

Appendix F

Commercial Air Conditioners and Heat Pumps Test Procedures

APPENDIX C TO SUBPART B OF PART 431- UNIFORM TEST METHOD FOR MEASURING THE ENERGY EFFICIENCY OF SMALL AND LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT, PACKAGE TERMINAL AIR CONDITIONERS AND HEAT PUMPS.

1. Scope: This appendix applies to the determination of energy efficiency of small and large commercial package air conditioning and heating equipment, package terminal air conditioners and heat pumps as defined in this appendix.

2.0 Definitions

2.1 "ARI" means Air-Conditioning and Refrigeration Institute.

2.2 "ARI Standard 210/240-94" means the test standard published in 1994 by the ARI and titled "Unitary Air-Conditioning and Air-Source Heat Pump Equipment."

2.3 "ARI Standard 310/380-93" means the test standard published in 1993 by the ARI and titled "Standard for Package Terminal Air-Conditioners and Heat Pumps."

2.4 "ARI Standard 320-93" means the test standard published in 1993 by the ARI and titled "Water-source Heat Pumps."

2.5 "ARI Standard 340/360-93" means the test standard published in 1993 by the ARI and titled "Commercial and Industrial Unitary Air-Conditioning and Air-Source Heat Pump Equipment."

3.0 Test Procedures

3.1 Testing Required and Test Conditions

3.1.1 Testing required and test conditions for small commercial package air conditioning and heating equipment.

3.1.1.1 Air-cooled small commercial package unitary central air conditioners and air-conditioning heat pumps rated below 65 kBtu/h cooling capacity. The required tests and tests conditions are those specified in ARI Standard 210/240-94 for obtaining the Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) defined in this ARI standard.

3.1.1.2 Air-cooled small commercial package unitary central air conditioners and air-conditioning heat pumps rated at or above 65 kBtu/h and below 130 kBtu/h cooling capacity. In the cooling mode, the required tests and tests conditions are those specified in ARI Standard 210/240-94 for obtaining the Energy Efficiency Ratio (EER) at the standard cooling rating conditions with 95 °F dry bulb entering air. In the heating mode for heat pumps, the required tests and tests conditions are those specified in ARI Standard 210/240-94 for obtaining the Coefficient of Performance (COP) at the standard heating rating point with 47 °F dry bulb entering air.

3.1.1.3 Water-cooled, evaporatively cooled and water-source small commercial air conditioners and air-conditioning heat pumps. In the cooling mode, the required tests and test conditions are those specified in ARI Standard 210/240-94 for obtaining the Energy Efficiency Ratio (EER) at the standard cooling rating conditions with 95 °F dry bulb entering air for evaporatively cooled equipment and with 85 °F entering water temperature for water-cooled and water-source equipment. In the heating mode for the water-source heat pumps, the required tests and tests conditions are those specified in ARI Standard 320-93 for obtaining the Coefficient of Performance (COP) at the standard heating rating point with 70 °F entering water temperature.

3.1.2 Testing required and test conditions for large commercial package air conditioning and heating equipment.

3.1.2.1 Large commercial air-cooled air conditioners and air-conditioning heat pumps. In the cooling mode, the required tests and tests conditions are those specified in ARI Standard 340/360-93 for obtaining the Energy Efficiency Ratio (EER) at the standard cooling rating conditions with 95 °F dry bulb entering air. In the heating mode for heat pumps, the required tests and tests conditions are those specified in ARI Standard 340/360-93 for obtaining the Coefficient of Performance (COP) at the standard high temperature heating rating conditions with 47 °F dry bulb entering air.

3.1.2.2 Large commercial evaporatively cooled and water-cooled air conditioners and air-conditioning heat pumps. The required tests and tests conditions are those specified in ARI Standard 340/360-93 for obtaining the Energy Efficiency Ratio (EER) at the standard cooling rating conditions with 95 °F dry bulb entering air for evaporatively cooled equipment and with 85 °F entering water temperature for water-cooled systems.

3.1.3 Package terminal air conditioner and package terminal heat pumps. In the cooling mode, the required tests and tests conditions are those specified in ARI Standard 310/380-93 for obtaining the Energy Efficiency Ratio (EER) at the standard cooling rating conditions with 95 °F dry bulb entering air. In the heating mode for heat pumps, the required tests and tests conditions are those specified in ARI Standard 310/380-93 for obtaining the Coefficient of Performance (COP) at the standard high-temperature heating rating conditions with 47 °F dry bulb entering air.

3.2 Testing procedures

3.2.1 Testing procedures for small commercial package air conditioning and heating equipment.

3.2.1.1 Air-cooled small commercial package unitary central air conditioners and air-conditioning heat pumps rated below 65 kBtu/h cooling capacity. The required tests shall be performed according to ARI Standard 210/240-94.

3.2.1.2 Air-cooled small commercial package unitary central air conditioners and air-conditioning heat pumps rated at or above 65 kBtu/h and below 130 kBtu/h cooling capacity. The required tests shall be performed according to ARI Standard 210/240-94.

3.2.1.3 Water-cooled, evaporatively cooled and water-source small commercial air conditioners and air-conditioning heat pumps. In the cooling mode, the required tests shall be performed according to ARI Standard 210/240-94. In the heating mode for water-source heat pumps, the required tests shall be performed according to ARI Standard 320-93.

3.2.2 Testing procedures for large commercial package air conditioning and heating equipment

3.2.2.1 Large commercial air-cooled air conditioners and air-conditioning heat pumps. The required tests shall be performed according ARI Standard 340/360-93.

3.2.2.2 Large commercial evaporatively cooled and water-cooled air conditioners and air-conditioning heat pumps. The required tests shall be performed according ARI Standard 340/360-93.

3.2.3 Testing procedures for package terminal air conditioner and package terminal heat pumps. The required tests shall be performed according to ARI Standard 310/380-93.